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No. I

Lieut.-General J. F. TENNANT, C.I.E., R.E., F.R.S., President,
in the Chair.

Oliver Joseph Lodge, D.Sc., LL.D., F.R.S., Professor of
Physics at the University College, Liverpool,
was balloted for and duly elected a Fellow of the Society.

The following candidates were proposed for election as Fellows
of the Society, the names of the proposers from personal know-
ledge being appended :—

Edward Herbert Lees, Orbost, Victoria, Australia (proposed
by R. L. J. Ellery);

John Samuel Slater, Professor of Civil Engineering, Civil
Engineering College, Seebpore, Calcutta (proposed by
A. M. W. Downing);

J. de Mendizábal Tamborrel, 13 Calle de Jesús, Mexico (pro-
posed by E. B. Knobel);

Arthur Thornton, M.A., Mathematical and Science Master,
Giggleswick School, Yorkshire (proposed by E. W.
Brown);

William Livingstone Watson, Ayton, Abernethy, Perthshire
(proposed by Ralph Copeland).

One hundred and ninety-one presents were announced as
having been received since the last meeting, including amongst
others :—

J. E. Gore, *Star Groups: a student's guide to the constella-
tions*, presented by the author; T. Cooke & Sons, *On the adjust-*

ment and testing of telescopic objectives, presented by the authors; F. W. Very, On the distribution of the Moon's Heat and its variation with the phase, presented by the author; Lick Observatory, Reports of observations of the total eclipse of the Sun, December 21-22, 1889, presented by the Observatory; T. W. Backhouse, The structure of the Sidereal Universe, presented by the author; L. Struve, Bestimmung des Mondhalbmessers, presented by the author; C. Flammarion, Copernic et la découverte du Système du Monde, presented by the author; W. Huggins, Address delivered at the Cardiff meeting of the British Association, presented by the author; Th. von Oppolzer, Traité de la détermination des orbites des comètes et des planètes, trad. par E. Pasquier, presented by Mr. R. E. S. Cooper; J. A. C. Oudemans, Die Triangulation von Java, Abth. III., presented by Professor Oudemans; the Photochronograph and its application to star transits, presented by Georgetown College Observatory; J. K. Rees, Catalogue of Prof. Rutherford's photographs, presented by Columbia College; Cincinnati Observatory, Charts and micrometrical measures of nebulae, presented by the Observatory; Lund Observatory, Observations de la zone $+35^{\circ}$ à $+40^{\circ}$, presented by the Observatory; Photographs of the Spectra of Solar prominences, presented by G. E. Hale; Photographs of the Cluster in *Hercules* and of *Jupiter*, taken at the Lick Observatory, presented by Professor Holden; Slater's Armillary Sphere, presented by Professor Slater; two drawings of *Jupiter*, presented by Mr. G. T. Gwilliam.

Note on the Lunar Theory. By Professor Cayley.

In the Lunar Theory, in whatever way worked out, the values ultimately obtained for the coordinates r, v, y should of course satisfy identically the equations of motion; and that they do so is the ultimate verification of the correctness of the results obtained. It can hardly be hoped for that such a verification will ever be made for Delaunay's results; and yet it would seem generally that the labour of such a verification of the results to any extent, while exceeding (and possibly greatly exceeding) that of obtaining these results by any method employed for that purpose, ought still to be, so to speak, a labour of the same order. And one can, moreover, imagine the process of verification so arranged as to be a process of mere routine which could be carried out by ordinary computers. But, however this may be, I think it is not without interest to exhibit the verification to a very small extent, viz. to e, m^4 .

I think there is an advantage in using capital letters for the arguments, and I accordingly write G (instead of Delaunay's g), to denote the mean anomaly.

The equations of motion are :

$$\begin{aligned}\frac{d^2r}{dt^2} - r \left\{ \cos^2 y \left(\frac{dv}{dt} \right)^2 \right\} + \frac{n^2 a^3}{r^2} &= \frac{d\Omega}{dr}, \\ \frac{d}{dt} \left\{ r^2 \cos^2 y \left(\frac{dv}{dt} \right) \right\} &= \frac{d\Omega}{dv}, \\ \frac{d}{dt} \left(r^2 \frac{dy}{dt} \right) + r^2 \sin y \cos y \left(\frac{dv}{dt} \right)^2 &= \frac{d\Omega}{dy}, \\ \Omega &= \frac{m' r^2}{r'^3} \left(\frac{3}{2} \cos^2 H - \frac{1}{2} \right), \text{ where } \cos H = \cos y \cos (v - v'),\end{aligned}$$

or say

$$\Omega = \frac{m^2 n^2 a'^3}{r'^3} r^2 \left\{ \frac{3}{2} \cos^2 y \cos^2 (v - v') - \frac{1}{2} \right\};$$

and thus the equations become

$$\begin{aligned}\frac{d^2r}{dt^2} - r \left\{ \cos^2 y \left(\frac{dv}{dt} \right)^2 + \left(\frac{dy}{dt} \right)^2 \right\} + \frac{n^2 a^3}{r^2} \\ = \frac{m^2 n^2 a'^3}{r'^3} r \left\{ 3 \cos \left\{ \frac{1}{2} + \frac{1}{2} \cos (2v - 2v') \right\} - \frac{1}{2} \right\}, \\ \frac{d}{dt} r^2 \cos^2 y \left(\frac{dv}{dt} \right)^2 = \frac{m^2 n^2 a'^3}{r'^3} r^2 \left(-\frac{3}{2} \cos^2 y \sin (2v - 2v') \right), \\ \frac{d}{dt} \left(r^2 \frac{dy}{dt} \right) + r^2 \sin y \cos y \left(\frac{dv}{dt} \right)^2 = \frac{m^2 n^2 a'^3}{r'^3} r^2 \left(-3 \sin y \cos y \frac{1}{2} + \frac{1}{2} \cos (2v - 2v') \right).\end{aligned}$$

To simplify as much as possible, take the Sun's orbit to be circular, i.e. $r' = a'$, $v' = mnt$; also neglect y^2 : the first and second equations are

$$\begin{aligned}\frac{d^2r}{dt^2} - r \left(\frac{dv}{dt} \right)^2 + \frac{n^2 a^3}{r^2} &= m^2 n^2 r \left\{ \frac{1}{2} + \frac{3}{2} \cos (2v - 2v') \right\} \\ \frac{d}{dt} r^2 \cdot \left(\frac{dv}{dt} \right) &= m^2 n^2 r^2 \left\{ -\frac{3}{2} \sin (2v - 2v') \right\};\end{aligned}$$

and if for convenience of working we write $a = 1$, $n = 1$, then the first equation may be written

$$\frac{1}{r} \frac{d^2r}{dt^2} - \left(\frac{dv}{dt} \right)^2 + \frac{1}{r^3} = m^2 \left\{ \frac{1}{2} + \frac{3}{2} \cos (2v - 2v') \right\},$$

and similarly the second equation is

$$\frac{1}{r^2} \frac{d}{dt} \left(r^2 \frac{dv}{dt} \right) = -\frac{3}{2} m^2 \sin (2v - 2v'),$$

and the third equation may be disregarded.

The two equations should be satisfied by Delaunay's values, putting therein $e' = 0$, $y = 0$; say by the values

$$\begin{aligned}
\frac{1}{r} = & 1 + \frac{1}{6} m^2 - \frac{179}{288} m^4 \\
& + \left(m^2 + \frac{19}{6} m^3 + \frac{131}{18} m^4 \right) \cos 2D \\
& + \left(\frac{7}{8} m^4 \right) \cos 4D \\
& + e \left(1 - \frac{7}{12} m^2 \right) \cos G \\
& + e \left(\frac{33}{16} m^2 \right) \cos 2D + G \\
& + e \left(\frac{15}{8} m + \frac{187}{32} m^2 \right) \cos 2D - G ;
\end{aligned}$$

$$\begin{aligned}
v = & t \\
& + \left(\frac{11}{8} m^2 + \frac{59}{12} m^3 + \frac{893}{72} m^4 \right) \sin 2D \\
& + \left(\frac{201}{256} m^4 \right) \sin 4D \\
& + 2e \sin G \\
& + e \left(\frac{17}{8} m^2 \right) \sin (2D + G) \\
& + e \left(\frac{15}{4} m + \frac{263}{16} m^2 \right) \sin (2D - G) ;
\end{aligned}$$

Where

$$D = (1 - m)t, \quad G = \left(1 - \frac{3}{4} m^2 \right) t, \quad (v' = mt).$$

The verification for the first equation is

	$\frac{1}{r} \frac{d^2 r}{dt^2} =$	$-\left(\frac{dv}{dt} \right)^2 =$	$\frac{1}{r^3} =$	$m^2 \left(-\frac{1}{2} - \frac{3}{2} (\cos 2v - 2v') \right) =$	
Const.		-1	+1	=0	
			$+\frac{1}{2} m^2$	$-\frac{1}{2} m^2$	=0
	$+2m^4$	$-\frac{121}{32} m^4$	$-\frac{9}{32} m^4$	$-\frac{33}{16} m^4$	=0
Cos 2D	$+4m^2$	$-\frac{11}{2} m^2$	$+3m^2$	$-\frac{3}{2} m^2$	=0
	$+\frac{14}{3} m^3$	$-\frac{85}{6} m^3$	$+\frac{19}{2} m^3$		=0
	$+\frac{64}{9} m^4$	$-\frac{539}{18} m^4$	$+\frac{137}{6} m^4$		=0
Cos 4D	$+8m^4$	$-\frac{161}{16} m^4$	$+\frac{33}{8} m^4$	$-\frac{33}{16} m^4$	=0
Cos G	e	$-4e$	$3e$		=0
	$-\frac{9}{4} em^2$	$+em^2$	$-\frac{3}{4} em^2$		=0
Cos 2D + G	$e \frac{193}{16} m^2$	$e \left(-\frac{73}{4} m^2 \right)$	$e \left(\frac{147}{16} m^2 \right)$	$e(-3m^2)$	=0
Cos 2D - G	$em \left(\frac{15}{8} \right)$	$em \left(-\frac{15}{2} \right)$	$em \left(\frac{45}{8} \right)$		=0
	$em^2 \left(-\frac{5}{32} \right)$	$em^2 \left(-\frac{187}{8} \right)$	$em^2 \left(\frac{657}{32} \right)$	$em^2(3)$	=0

That the second equation is

$$\frac{2}{r} \frac{dr}{dt} \cdot \frac{dv}{dt} = + \frac{d^2 v}{dt^2} = + \frac{3}{2} m^2 \sin(2v - 2v') =$$

Sin 2D	$+4m^2$	$-\frac{11}{2}m^2$	$+\frac{3}{2}m^2$	$=0$
	$+\frac{26}{3}m^3$	$-\frac{26}{3}m^3$		$=0$
	$+\frac{142}{9}m^4$	$-\frac{142}{9}m^4$		$=0$
Sin 4D	$+\frac{21}{2}m^4$	$-\frac{201}{16}m^4$	$+\frac{33}{16}m^4$	$=0$
Sin G	$e \cdot 2$	$+e \cdot -2$		$=0$
	$e \cdot 3m^2$	$+e \cdot 3m$		$=0$
Sin 2D + G	$e \cdot \frac{129}{8}m^2$	$e \cdot -\frac{153}{8}m^2$	$e \cdot 3m^2$	$=0$
Sin 2D - G	$e \cdot \frac{15}{4}m$	$e \cdot -\frac{15}{4}m$		$=0$
	$e \cdot \frac{71}{16}m^2$	$e \cdot -\frac{23}{16}m^2$	$e \cdot -3m^2$	$=0$

and the verification is thus completed.

The following intermediate results may be recorded ; $\frac{1}{r} = 1 + \chi$,

$$\chi^2 = - \log r = \frac{dv}{dt}$$

	$\frac{19}{36}m^4$	$\frac{1}{6}m^2 - \frac{255}{288}m^4$	1
Cos 2D	$+\frac{1}{3}m^4$	$m^2 + \frac{19}{6}m^3 + \frac{64}{9}m^4$	$\frac{11}{4}m^2 + \frac{85}{12}m^3 + \frac{539}{36}m^4$
Cos 4D	$+\frac{1}{2}m^4$	$\frac{5}{8}m^4$	$\frac{201}{64}m^4$
Cos G	$+\frac{1}{3}em^2$	$e\left(1 - \frac{3}{4}m^2\right)$	$e\left(2 - \frac{3}{2}m^2\right)$
Cos 2D + G	$+em^2$	$e\left(\frac{25}{16}m^2\right)$	$e\left(\frac{51}{8}m^2\right)$
Cos 2D - G	$+em^2$	$e\left(\frac{15}{8}m + \frac{171}{32}m^2\right)$	$e\left(\frac{15}{4}m + \frac{143}{16}m^2\right)$

$$\frac{1}{r} \frac{dr}{dt} =$$

Sin 2D	$2m^3 + \frac{13}{3}m^3 + \frac{71}{9}m^4$
Sin 4D	$\frac{5}{2}m^4$
Sin G	$e\left(1 - \frac{3}{2}m^2\right)$
Sin 2D + G	$e\left(\frac{75}{16}m^2\right)$
Sin 2D - G	$e\left(\frac{15}{8}m + \frac{51}{32}m^2\right)$

These were in fact made use of for finding the foregoing values of r , $\frac{d^2 r}{dt^2}$, &c.

Colour Changes in the Markings on the Surface of the Planet Jupiter.
By E. E. Barnard.

During the twelve years that I have observed *Jupiter* I have often been struck with the decided changes of colour in the different markings on his surface. A careful study of the numerous details during this time has led to the discovery that the red colour of any of the markings is an indication of their age; or, in other words, when a spot or marking (other than the white spots) first appears it is dark or black, but after some time turns red. I have repeatedly predicted to myself this transition upon the appearance of a dark spot, and have yet to find the first instance of a deviation from this striking rule.

As an illustration, I would mention a few cases in my own experience. The remarkable black spots of 1880 which appeared on the northern hemisphere of the planet in October and November of that year were at first black, and then terminated their career by forming a red belt around *Jupiter* (see *Publ. A. S. P.* No. 5).

The small inky-black spots which appeared on the northern edge of the equatorial belt in 1890 soon turned red, and are now almost the reddest objects on the planet.

The new red spot, which lies on a parallel with the southern edge of the great red spot, and follows it by about 140° , when first seen by me in the early part of August 1890, was dark, with no trace of red. It is now the most conspicuous object on the planet, and is of a deep red colour.

There is another marking similar to this in the same latitude, and preceding the great red spot by an hour or so. When first seen this was dusky, with no trace of red. On August 14 last I wrote in my note-book: "This dusky oblong marking has no trace of red now; perhaps it will turn red." It is now of a strong red colour.

I have noted this transformation in a number of other cases. It would, therefore, appear certain that as a rule markings of this class first appear dark, and later turn red.

I have been curious to know if the great red spot in its early history was also governed by this rule. When I first saw it in 1879 it was a deep red, and has been so ever since, except where partially obscured by white clouds, during the past six or seven years. I have fortunately found two early observations of this spot in 1872. These fully prove that the great red spot is no exception to the rule. In the *Observatory* for 1882, vol. v. p. 21, Mr. H. Corder says, in speaking of his observations of this object in 1872, March 13: "Its colour was not noted as red." In the same volume, p. 55, M. Terby confirms Mr. Corder's statement about the absence of colour in the spot. He has an observation 1872, January 28, and, referring to this, says: "I ought

to say, with Mr. Corder, that I did not remark any special tint in this spot. I observed it merely as a dark spot, grey or black, with the *same* instrument which to-day shows me the red colour of this remarkable object in so striking a manner."

From a knowledge of the time occupied by the dark phase of the spots, I think it would be safe to say that the great red spot was not many months old when seen by Mr. Corder and M. Terby in 1872.

This rule seems to apply also to the equatorial belts. The darker portions would therefore appear to be new or recent formations.

Mount Hamilton:
1891 September 30.

*Observations of the Spots and Markings on the Planet Jupiter,
made with the Twelve-inch Equatoreal of the Lick Observatory.
By E. E. Barnard.*

I have already communicated a series of observations and measurements of the markings on the planet *Jupiter* to the Royal Astronomical Society. I have continued these observations this year, and herewith present the results.

The planet has been extremely interesting at this opposition, from the remarkable amount and variety of detail displayed upon his surface. As usual, the two hemispheres have been strongly contrasted in their individual markings. In the southern hemisphere, besides the great red spot, new red spots have appeared, and a great number of round white spots have been visible. These objects are characteristic of the southern hemisphere, though individual white spots have at rare intervals been seen in the northern hemisphere. In the northern half of the planet a system of small dark spots has appeared. These have extraordinary short periods of rotation. The northern regions have also exhibited many features of detail. These have, however, been dark and obscure.

The great red spot has regained much of its former distinctness both in colour and form.

Observations have been made of the relative light and size of the four satellites. These will be continued. The fourth satellite seems to vary considerably in its light.

The following observations and remarks are the result of an examination of the planet with the 12-inch equatoreal of this observatory. The times are Mount Hamilton mean time.

The transits have been obtained by bisecting the equatorial belts by a vertical micrometer wire, and noting when the object passed behind this wire.

In the tabulation of the measures, N means distance from north limb of the planet, and S the reverse.

Small Oblong Dusky Spot in the Southern Hemisphere.

		Transit		λ	N.	N. $5^{\circ}20'$	S.	S. $5^{\circ}20'$
		h	m					
1891	Sept. 21	11	17.4	214.4	...	...	...	...
	Oct. 4	6	51.3	208.3	35.7	28.1	10.1	8.0
	8	10	11.2	209.9	...	...	...	...

On Oct. 4 the length of this object was $1''.7$, and its breadth $0''.8$. Dark at first, it gradually assumed a tinge of red. On the last date, a very small spot closely preceded it. Its longitude diminishes about $0^{\circ}.47$ daily.

Small Black Spots in the Northern Hemisphere.

In 1880, during October and November, it will be remembered, a number of remarkable black spots broke out on a fine linear belt just north of the equatorial belts. These objects were possessed of an extraordinary relative motion. After many singular and remarkable transformations, they finally formed a diffused red belt about the planet.

During the present year, a number of small dark spots have appeared in identically the same location. They also have an extraordinary velocity of rotation. With the exercise of a good deal of care, I have succeeded in identifying certain of these spots, and have observed them at different transits..

Following are the observations of these interesting markings. They are all located in the same latitude:—

		<i>Spot a.</i>						
		Transit		λ	N.	N. $5^{\circ}20'$	S.	S. $5^{\circ}20'$
		h	m					
1891	Sept. 17	8	51.4	244.9	16.0	12.3	31.5	24.2
	21	11	1.6	205.9	...	...	...	...
	Oct. 2	12	6.2	97.9	...	...	...	...

This is the following of three.

		<i>Spot b.</i>		
		Transit.		λ
		h	m	
1891	Sept. 28	7	45.3	58.7
	Oct. 4	11	3.1	0.2
	5	6	42.8	353.2
	7	7	45.0	331.4

The following of three.

		<i>Spot c.</i>		
		Transit.		λ
		h	m	
1891	Sept. 28	7	0.9	31.9
	Oct. 2	9	15.7	354.7
	7	7	9.2	309.8

The first of three.

Spot d.

	Transit.	λ
	h m	
1891 Oct. 4	9 38.8	309.3
7	6 30.2	286.3

This is an isolated spot.

Following are transits of a few more of these dark spots which I have not identified with certainty at successive observations, though some of them may be identical:—

	Transit.	λ	
	h m		
1891 July 11	14 0	285.0	Isolated spot.
Sept. 3	7 59.7	268.1	The first of three.
18	10 19.5	88.4	The first of three. Perhaps the first of a chain of spots.
Oct. 4	6 46.6	205.3	The second of two isolated spots.
5	7 24.3	18.1	First of a chain of dark spots.

All the foregoing spots are located on a narrow belt in the northern hemisphere, the position of which on September 9 was

Distance from North limb = 14".8 one obs.

Distance from South limb = 32.9 one obs.

The spots extend in a broken chain around the planet and have a relative motion (when referred to Marth's Meridian II.) of 9°.80 daily. They complete a revolution around *Jupiter* in about 37 days. They were first seen by me.

The New Oblong Red Spot in the Southern Hemisphere.

The history of this object dates from last year. It rather rapidly formed near the great red spot, as an oblong, dusky marking in the first part of August 1890. Like the other new red spot now visible on the southern hemisphere, its first appearance near the great spot might suggest some connection with that object and their origin.

Its longitude diminishes about 0°.54 daily. It is clearly defined and of a strong red colour—by far the most noticeable object on the planet. Its period of revolution around *Jupiter* is about 667 days, or less than two years, as referred to the great red spot. Its motion may be slightly variable. About 1892, June 1, it will again pass the red spot, skirting the southern edge of that object at its nearest approach.

		Transit.	λ	S.	S. 5'20	N.	N. 5'20.	Length.	L. 5'20.
		h m							
1891	July 13	12 44	179°6	11'3	9'5	32'2	27'1	8'4	7'0
	25	12 33	177'2	11'1	9'0	33'7	27'4	9'3	7'6
	30	12 25 4	168'3	10'8	8'6	33'8	27'0	10'1	8'0
Aug.	1	13 5'9	169'8	...	...	...	...	...	...
	9	9 35'4	165'9	...	...	...	...	...	...
	21	9 15'7	158'6	...	...	...	...	...	...
	23	10 52'8	158'4	11'7	9'0	34'9	26'8	...	...
	28	9 54'4	155'1	11'5	8'8	34'6	26'5	...	...
Sept.	7	8 2	151'5	...	...	...	...	...	...
	16	10 17'3	146'3	11'2	8'6	34'5	26'5	...	...
	18	11 51'9	144'2	11'4	8'8	34'7	26'7	...	...
Oct.	3	9 3'8	137'7	...	...	...	...	...	...
	6	6 32'1	136'9	11'0	8'7	34'6	26'7	...	...

The apparent breadth of this object on July 25 was 0''·8.

There was a small white spot at its preceding end throughout the observations.

The Large White Spots in the Southern Hemisphere.

I have observed several of these objects. Their rotation periods are about the same as those of the new red spots. Their longitudes decrease about 0°·6 daily.

		Spot A.						
		Transit.	λ	N.	N. 5'20.	S.	S. 5'20.	
		h m						
1891	July 27	12 46	125°9	...	...	...	...	...
	29	14 16	121'0	...	...	...	...	...
Aug.	1	11 48	122'7	...	...	...	...	...
	8	12 26'5	118'7	...	...	...	...	...
	10	13 58	114'9	35'4	27'7	9'6	7'6	
	23	9 35'7	111'8	36'2	27'8	10'6	8'1	
	25	11 11'1	110'0	...	...	...	...	
Sept.	16	8 53'5	95'6	35'6	27'4	10'3	7'9	
	18	10 32'0	95'9	...	...	...	...	

		Spot B.					
		Transit.	λ	S.	S. 5'20.	N.	N. 5'20.
		h m					
1891	Aug. 12	12 40	8°6	...	...	...	...
	20	9 4'6	1'6	10'1	7'8	36'7	28'2
	27	9 42'1	357'4	10'9	8'4	36'4	27'9
Sept.	8	Transit not obsd.		10'6	8'1	36'6	27'9
	17	11 41'1	347'4	11'3	8'7	35'7	27'5

This was a very luminous spot, which passed close, skirting the southern edge of the great red spot. Measurements were made of its position to detect any displacement in latitude during its passage of the red spot.

The latitude did not sensibly change, and the great spot seemed to exert no repellent force against it.

It was first seen in the first part of August, when it was taken for a satellite in transit.

Spot C.

	Transit. h m	λ	N.	N. 5°20	S.	S. 5°20.
1891 Sept. 11	8 56.5	65°5	35"8	27"4	10"3	7"8
16	7 54.7	60.2	36.7	28.2	9.4	7.2
Oct. 3	6 35.2	48.0	...	...	...	...

This object has a peculiar wisp of dusky matter extending southwards from it.

Long Red Spot in Southern Hemisphere.

	Transit. h m	λ	Length.	L. 5°20.
1891 Sept. 17	10 17.3	296°8	...	...
Oct. 2	7 16.0	282.5	14	11
7	6 24.3	282.7	12	10

This object was first seen some time previous to August 12, when it was south preceding the great red spot. It was then dark, with no trace of red. From August 21 it began to turn red, and by September 17 was of a strong red colour. The first two transits are rough, and the measures of its length are very approximate. It is in a latitude very slightly south of that of the southern edge of the great red spot. These remarkable red strips, now so prominent in the southern hemisphere, seem to have their origin in the region of the great red spot, where they first appear as dark markings.

The Great Red Spot.

The great red spot seems to be stationary in longitude; the motion appearing to be the same as that assigned to Marth's System II. If this is so, the following observations would indicate a probable error of $\pm 0^{\circ}.44$ or $\pm 0^m.73$ in the determination of the time of transit by a single estimate.

Professor Hough, from a fine series of micrometer measures, in 1880, deduced a probable error of $\pm 0^m.9$ in the time of transit from a single pair of measures, and thinks the micrometer method far preferable to any method of eye-estimates. Careful eye-estimates, however, I think, should have the same value as micrometer measures for determining the lines of transit of the spots on *Jupiter*. I have had a few previous remarks on this subject in a paper on the planet, printed in No. 5 of the *Publi-*

cations of the *Astronomical Society of the Pacific*. (See pp. 91-92).

The colour of the great spot has been much stronger this year, and its form more definite than for a good many years. It still remains the slowest rotating object on the planet.

I have been in hopes that some of the round white spots—so abundant in the southern hemisphere—would make their appearance in the same latitude as the red spot, so that their motion would carry them over or under it; but they seem to be confined to a region the northern limit of which is parallel with the southern edge of that spot.

One object, apparently connected with the history of the red spot, and which was a prominent feature last year, has been wholly missing during the present apparition of the planet: this was a curious reddish streak emanating from the southern edge of the equatorial belt north preceding the red spot, and which, curving southwards, passed along parallel to the equatorial belt in a preceding direction. It was a perfectly symmetrical outline of the "bay" formed north following the red spot by the equatorial belt. This was visible throughout last year, and seems to be a recurring feature, since it has repeatedly appeared and disappeared within the past twelve years, always appearing in the same position. The "bay" referred to has been very marked this year.

Careful examination, under the best conditions this year, have shown that the dark belt south of the red spot is entirely free from the edge of that object, a clear space of about $\frac{1}{4}''$ being visible between them.

The observations seem to show that the great spot is shorter this year than in 1880, and it is perhaps broader.

Following are observations of this object:—

	Transit	λ	Apparent Length.	L 5'20	N.	N. 5'20	S.	S. 5'20
1891	h m	o	"	"	"	"	"	"
June 3	...	...	9'5	9'1	...	...	...	...
	5 16 27.3	3.2	...	...	...	...	...	...
July 14	13 38.3	2.8	...	...	...	...	...	...
Aug. 2	14 15.0	2.0	...	...	...	...	...	...
	12 12 31	3.1	...	...	...	...	...	...
	20 9 26	2.5	...	...	...	...	...	...
	27 9 54	4.3	...	...	...	...	...	...
Sept. 3	10 37.2	3.3	...	...	...	...	...	...
	17 12 6.0	2.4	...	...	...	...	...	...
	18 7 57.4	2.5	12.7	9.8	32.2	24.7	13.3	9.8
Oct. 2	9 29.6	3.1	...	...	32.4	25.4	13.7	10.7
	5 6 57.7	2.2	...	...	...	...	...	...

Width Sept. 18 = $6''\cdot 0$ ($4''\cdot 7$ at Δ 5'20).

The preceding end transited 1891, June 3^d 15^h 11^m·7, giving $\lambda=16^{\circ}9$.

The two principal members of the system of small dark red spots which were visible last year on the northern edge of the equatorial belt, and which I have designated as spots 1 and 2, have been regularly observed and measured this year. Though not as conspicuous as when seen in April of last year, they are very distinct, and of a deep red colour. Last year the measures did not indicate with certainty any relative motion in the two. This year, however, the distance between them has diminished considerably—about 2". The latest observations show that the distance reached a minimum in the end of August, and seems now to be slowly increasing.

Mean distance 1890	.	.	.	7 ["] 64
Mean distance 1891	.	.	.	5 ["] 58

I have collected my observations made of these spots this year in the following table, where Δ is the observed distance between them and $\Delta 5'20$ the value at *Jupiter's* mean distance. The measures under the headings N and S are the measured distances from the north and south limbs of the planet.

Since the first observations of these spots in 1890 April 26, they have slowly drifted through 104° of longitude at the rate of $0^{\circ}253$ daily. They will make a complete revolution about *Jupiter* in 3·9 years.

		Spot 1.	λ	Spot 2.	λ	Δ	$\Delta 5'20$	N.	N. 5'20	S.	S. 5'20
1891		h m		h m	$^{\circ}$						
July	4	12 33	259°9	...	...	7 ["] 4	6 ["] 4	15 ["] 9	13 ["] 7	25 ["] 6	22 ["] 1
	28	12 9	254°1	12 43	257°2	8·2	6·6	17·7	14·2	26·8	21·6
Aug.	9	12 1	254°1	...	...	7·0	5·5	17·8	14·0	27·5	21·6
	14	...	...	11 35·1	270°2	6·5	5·1	17 7	13·8	28·5	22·2
	19	10 11·9	252°2	...	...	7·3	5·2	...	...	...	...
	24	...	...	9 41·6	265°7	6·0	4·6	...	...	...	...
Sept.	7	10 42·3	248°1	...	...	6·7	5·1	18·2	13·9	28·3	21·6
	9	...	...	12 51·1	266°6	...	...	...	...	...	...
	17	10 39	244°9	...	...	7·0	5·4	18·3	14·0	29·5	22·6
	26	...	...	11 41·1	261°6	7·3	5·7	18·6	14·5	29·3	22·7
Oct.	3	11 58·2	243°0	...	...	7·8	6·1	...	...	...	...
	4	7 42·1	238°8	8 13·1	257°5	7·2	5·7	17·7	13·9	27·6	21·8

Phenomena of the Satellites.

1891 July 11^d 13^h 39^m 6^s. Reappearance of II. from occultation. Bisection.

1891 July 27^d 12^h 53^m 43^s. Transit of II. egress. Bisection.

1891 August 10^d 13^h 59^m 24^s. Conjunction of I. and II.

The two satellites appeared like a close double star, but well separated.

1891 August 12^d 11^h 58^m 13^s. Central transit of III. It crossed the bright surface of *Jupiter* as a large dark grey spot. The following are measures of its position at mid-transit:—

From South limb	.	.	.	11 ^{''} 7
From North limb	.	.	.	34 [°] 0

1891 August 12^d 12^h 5^m 12^s. Reappearance of II, from occultation. Bisection.

1891 August 21^d 8^h 58^m 33^s. Transit II. egress. Bisection.

1891 Oct. 1^d, between 9^h and 10^h. III. in transit as a dark spot.

1891 October 6^d 6^h 42^m 25^s. Transit I. egress. Bisection.

1891 October 6^d 7^h 13^m 13^s. Transit, egress IV. Bisection. Position at 6^h 22^m 2.

From North limb	.	.	.	36 ^{''} 2
From South limb	.	.	.	8 [°] 6

It appeared as a large very dark spot, and was dark up to the moment of egress.

Phenomena of the First Satellite.

The first satellite has been observed on all favourable occasions with the 12-inch, to determine, if possible, the explanation of the phenomenon of 1890, September 8, when it appeared distinctly double at transit.

As I have previously remarked, the conditions for a reobservation of that phenomenon will not be suitable until at least 1892, since the satellite now transits the southern dark equatorial belt, and therefore cannot be seen dark in transit.

My observations have been confined principally to the 12-inch, the scale of which is too small to settle definitely the phenomena exhibited in the transits of the satellites. On several occasions I have, however, been able to examine the satellite in transit with the 36-inch refractor.

The phenomena seen on these occasions would rather discourage the idea of actual duplicity. At these times the satellite has appeared egg-shaped when in relief on the dark belt.

This elongation cannot be due to any malformation of the satellite, since that object has always appeared perfectly round only a few minutes before the elongated phase, the transition being rather sudden. I am confident that this particular phase, and perhaps also that of apparent duplicity, is explained by a bright belt on the satellite, or by darkness of its polar regions, which is the same thing. This I have explained in a previous communication (*Monthly Notices*, vol. li. 557). I cannot, however, account

for the egg-shaped appearance of the satellite, unless it be due to a local excursion of the darker polar caps towards the equator of the satellite. If such is the case, I. must rotate on its axis in a time different from that of its period of revolution, as I have seen this pointed or wedge-shaped appearance sometimes preceding and at other times following the centre of the satellite, at observations separated by no great intervals, and this in the same position on the disc of *Jupiter* (1891 August 3, small end preceding. September 11, small end following. September 18, small end following).

At times this elongation is perfectly parallel to the belts of *Jupiter*; at other times it is inclined 7° or 8° to them. In my previous communications on this subject I have spoken of the position angle of apparent duplicity or elongation. I should have stated that these position angles were referred to the north pole of *Jupiter*, and not to a celestial meridian.

Following are notes with reference to the subject in hand:—

1891 July 4^d 13^h 27^m 13^s, with the 12-inch, the first satellite bisected at transit egress. Before emergence it was seen as a dusky spot, apparently round. At last contact it was certainly perfectly round.

1891 July 11, with the 12-inch. Carefully watched for a dark transit of I. After entering some distance, the satellite entirely disappeared, blending into the dark belt. Its shadow was black and round when well on the disc. At 15^h the satellite was visible as a small pale white spot on the south belt.

1891 July 27, with the 12-inch. Carefully watched the satellite. It became visible as a very faint dark spot when about one-fifth across. At 12^h 13^m it was near the middle of its path. It was impossible to make out its form, since the contrast was too small. The shadow was round.

1891 August 3. The satellite observed in transit with the 36-inch. Shadow was large and round when well on the disc at 13^h $\frac{1}{2}$. I. was very much elongated. It was egg-shaped, the small end preceding. Position angle (from Jupiter's north pole) $265^{\circ} \pm$. The observations on this date have already been sent to the *Monthly Notices*.

1891 September 4. 36-inch. The satellite transited partly covering its shadow. It could not be seen when in mid-transit, but became visible when about four-fifths across. It then appeared perfectly round and partly overlapped its shadow, which appeared as a crescent, joining the north preceding side of the satellite. There was no marking of any kind visible on I., which was watched until egress. Mr. Burnham observed the transit with me.

1891 September 11. 36-inch. Mr. Burnham and I carefully examined I. in transit. The seeing was very poor, but occasionally, during moments of good definition, the satellite was decidedly elongated to both of us. It was egg-shaped with the small end following. The elongation was parallel to the belts of

Jupiter. These observations were made when the satellite was one-fourth across. It was examined again when about four-fifths across. The elongation and egg-shaped appearance were the same, but the seeing had become so poor that its form could not be clearly distinguished at exit.

1891 September 18. 36-inch. Mr. Burnham and I examined the satellite in transit. Before entrance it was perfectly round, and there seemed to be a small dark spot in its centre, which may have been optical. It remained round for a short time after entering upon the planet, but when about one-sixth across, it became elongated in a line perfectly parallel with the belts of *Jupiter*. The elongation was conspicuous. Both Mr. Burnham and myself agreed as to the rapid transition from a round to an elongated object. The following end of the satellite was unquestionably the smaller. The elongation was as nearly as may be 2×3 . Watched it closely from the time of contact at entrance until $0^h 20^m$ sidereal. Seeing = 4. During this time, II. following the planet was round.

1891 October 3. 12-inch. The satellite was examined before transit, when it was perfectly round; it was also round at entrance. It soon became lost in the dark belt. The scale of the 12-inch was too small to be certain of its form when disappearing, but it seemed to be elongated. Bisection at entrance $10^h 1^m 41^s$. The seeing was perfect.

The Nature of the Surface of Jupiter.

After observing the planet for some twelve years I can hardly advocate the theory that the visible surface of *Jupiter* is a cloud surface.

It would seem to me more consistent with the observed phenomena to suppose the surface to be in a plastic or pasty condition, the belts and markings being merely discolorations in this, due to internal eruptions. This would easily account for the observed permanence of certain of the markings and for their colours. I do not think the cloud theory can account at all satisfactorily for the continued permanence of the various markings. The colours and changes of colour are also against it. If we assume the plastic theory, it is readily seen how the dark markings may be matter brought up to the surface by internal disturbances, and which by exposure on the surface is subject to changes of form and colour. Or possibly one might combine the two theories, and account for any shortcomings in the plastic theory by supposing local clouds of steam near or on the surface. I do not know to what extent the small density of the planet may militate against this, but the theory certainly seems worthy of consideration.

Perhaps this idea has been advanced before, as it seems a natural one: if so, I have not seen it.

Mount Hamilton:
1891 October 9.

On the supposed Duplicity of the First Satellite of Jupiter.

By A. Stanley Williams.

With reference to the remarkable apparent duplicity of the First Satellite of *Jupiter* observed by Mr. Barnard on September 8, 1890, and of which he gives an account in the *Monthly Notices*, vol. li., p. 547, I would ask whether it is quite certain that the observed phenomenon may not have been due to the satellite being seen in transit as a dark spot close to a dark spot on the surface of *Jupiter*. Such an explanation would, of course, be out of the question in the case of an observer of so much experience as Mr. Barnard, if the observation could have been continued during a considerable part of the time that the satellite was on the disc of the planet, since the difference in the rate of motion of the two spots could not in such case have escaped being noticed. But Mr. Barnard expressly states that the observation was interrupted, and that it was not possible to follow the satellite closely owing to the presence of visitors. And the explanation now suggested assumes greater probability when considered in connection with the observation referred to below, since it will appear that there was actually a little spot on the surface of the planet exactly in the position necessary to give rise to the observed duplicity. The explanation ingeniously set forth by Mr. Barnard in his note on p. 557 of vol. li. of the *Monthly Notices* appears to me inadequate to account for the observed appearance, since it would require the satellite to be much larger than it actually is.

On September 5, 1890, three days before Mr. Barnard's observation, *Jupiter* was observed by the writer with a $6\frac{1}{2}$ -inch Calver reflector, powers 150 and 225. A little dark spot was noticed in the middle of the bright equatorial zone, exactly in the position of the southernmost component of the double spot represented by Mr. Barnard in his figure (Plate 14, fig. 4). The spot was slightly oval in shape, and about $1''$ in length. It was observed to be in mid-transit at $8^h 42^m.8$. It therefore followed the zero meridian of System I. of Mr. Marth's Ephemeris (*Monthly Notices*, vol. l., p. 346), by $3^h 30^m.7$. The motion of the markings in the equatorial region of *Jupiter* agreed closely last year with this ephemeris, so that in an interval of a few days there would be no appreciable difference.* The little dark spot would therefore have transited at $15^h 26^m.7$ G.M.T. on September 8. According to the *Nautical Almanac* the

* The above spot was so small and delicate that, in the unfavourable position of the planet last year, it could not be continuously observed. But a little preceding it was another similar, but larger and plainer, spot, and the

first satellite was in mid-transit on that night at $15^h 27^m$, and it would be seen projected on the bright surface of the equatorial zone just north of the planet's equator. Consequently, when in mid-transit, the satellite would have been seen as a dark spot just north of the above-mentioned spot, and the two would have appeared as a close double spot. In other words, the appearance would have been almost exactly that represented by Mr. Barnard in fig. 4, Plate 14. Whether this explanation be considered sufficient or not, it appears to me very important that the presence of this little dark spot should be placed on record.

In conclusion, I may mention that the first satellite was visible in dark-transit on July 26, 1890, in nearly the same position relative to the belts as the northernmost of the two spots shown in Mr. Barnard's sketch, but a little nearer to the equator. Since the elevation of the earth above the plane of *Jupiter's* equator was $-0^\circ 297$ on July 26, compared with $-0^\circ 402$ on September 8, the position of the satellite on the latter date should have agreed very closely with that of the northernmost of the two spots in fig. 4, Plate 14.

Burgess Hill:

1891 November 7.

Note on some Photographs of Jupiter taken with the Five-foot Reflecting Telescope. By A. A. Common, LL.D., F.R.S.

A new mirror for the 5-foot telescope was completed in July, and some experiments have been made in photographing *Jupiter* to determine the exposure necessary and the definition obtainable. With the primary image a good picture is obtained with the quickest exposure that can be given by hand. About 2^s gives a dense image and all the visible satellites, with an enlarging lens giving an image of about $\frac{1}{2}''$ 3^s to 6^s gives ample density, up to 1 inch from 8^s to 10^s gives sufficient density. For further enlargement the time is, of course, proportional. About $1\frac{3}{4}$ -inch diameter is the largest we have tried, but this was done on an unfavourable night.

following observations of it will show that its motion did not differ greatly from Mr. Marth's System I. :—

Date.	G.M.T. of Transit.	Longitude, System I.
1890.	h m	
Aug. 1	11 46.5	111° 4'
3	13 5.8	115.8
Sept. 9	10 55.6	121.1
Oct. 9	9 23.2	119.9
12	6 20.5	121.9

It was also seen on September 5, but the time of its transit was not recorded.

With regard to the definition, the detail on the planet is not so well given as in the Lick photographs, though closely approaching in the best photographs to this. With an enlargement to a diameter of $\cdot 8$ of an inch, the satellites are fairly round, and about the proportionate size, though rather faint, the exposure being about 7^s . These photographs were taken with this exposure for the planet, and I did not expect to see any trace of the satellites. Photographs taken on this night, September 8, at short intervals of time, show Sat. II. emerging from the limb, while the shadow is still visible on the disc. When the satellite is well clear, the shadow seems to cut a piece out of the limb.

Another photograph on September 10 shows this with Sat. III. in a similar manner.

Several photographs taken on September 15 show Sat. II. and its shadow in transit. The red spot shows in a most marked manner in many. From an examination of the enlarged image of the planet, and also of the limb of the Moon, it appears to me that definition depends very much on the atmospheric conditions. In looking at the image enlarged on very fine ground glass, there are moments when the image is very sharp and steady. Then the image becomes blurred, and good definition disappears for a few seconds. The nights have been too few to determine whether this is a permanent condition of things, probably there may be nights when the definition is good continuously.

The Reappearance of Saturn's Ring. By the Rev. A. Freeman, M.A.

With the aid of a 6-inch refractor by Simms, lent to me by the Royal Astronomical Society, and having a focal length of 7 feet and a magnifying power of 180, I have fortunately obtained very fine views of *Saturn* in the early mornings of October 29, 30, 31, November 2 and 3. The sky was unhappily overcast on November 1, and from November 4 to 9. The description of what was seen follows:—

October 29, $5^h 55^m$ A.M. (civil time).—*Saturn's* elliptical disc is crossed by a dark band, its breadth about one-tenth of the length of the polar diameter of the planet. The north edge of this band seems to be on the equator of the planet. The equatorial bright belt, which is yellowish, seemed about half the breadth of the dark band, which is, of course, the unilluminated north side of the rings. I could see no division in this band. The first southern dusky belt is visible, and the rest of *Saturn's* disc is of a pale white colour except at the poles, which are dusky. The crescent moon is only about 4° to the east of *Saturn* and nearly at the same altitude. *Titan* ceased to be visible at $6^h 30^m$.

October 30, 6^h 10^m A.M. to 6^h 20^m A.M.—The best view at 6^h 15^m A.M. The broad dark band across *Saturn's* elliptical disc is wholly south of the equator, with its north edge almost on the equator. The band is very sharply defined, and is of an indian-ink colour, the general colour of the brighter parts of *Saturn* pale white, that of the equatorial bright belt a pale yellow. The breadth of the band estimated to be one-tenth of the length of the polar diameter. The south edge of the band seemed to be *very slightly curved*, with convexity southwards. The breadth of the equatorial bright belt is to-day about two-thirds that of the dark band. Two dusky belts visible south of the dark band and one north. The north pole a shade darker than the south pole.

October 31, 6^h 25^m to 6^h 35^m A.M.—The view at 6^h 30^m A.M. showed the broad dark band very distinctly, its north edge on *Saturn's* equator. The yellowish equatorial bright belt north of the equator *is as broad as the band*, which seems a little narrower than yesterday. The distance of the band from a dusky belt south of it is equal to the breadth of the band. There is not to-day, nor was there on the two previous days, any trace whatever of the ansæ of *Saturn's* ring. At 6^h 32^m A.M. a remarkable bright round spot was entering over the east limb of *Saturn* upon the equatorial bright belt, and it was wholly within the limb and wholly upon the bright belt at 6^h 36^m. It appears to follow spot 2^a of Mr. A. S. Williams's spots (*Astron. Nach.* No. 3051) about half a rotation. Mr. Williams confirms this view.

November 1, 6^h A.M.—The sky wholly overcast with clouds. The same was the case, as I am informed, at Cambridge Observatory.

November 2, 5^h 30^m.—On the very first view the ring was plainly visible as a fine bluish line of some breadth on the preceding side, its length about five-eighths of the diameter of *Saturn*; it was also seen, but not so easily, as a faint bluish narrower line on the following side, and of nearly the same length. The power used was 150 only. *Enceladus*, *Tethys*, *Rhea*, *Titan* and *Iapetus* were also visible. (*Dione* was not seen separate from *Rhea*, it was probably closer to *Rhea* than the 8'' which would be given by Marth's Ephemeris.) I soon changed to the higher power of 180, which also has better definition, and at 5^h 45^m A.M., I found the breadth of the blue ansæ at the limb to be equal to that of the dark band, very nearly if not quite. The colour of the ansæ was a vivid electric-light blue, streaked with white in general direction nearly parallel to *Saturn's* equatorial axis. The white was probably the colour reflected by the brightest parts of the inner and outer rings. I saw that the dark band was divided near the limbs of the planet by fine bright lines, one near each limb, but I could not with certainty trace the division right across the dark band. The bright division could not, according to Trouvelot, represent a view of *Saturn* seen through the Cassini gap; it was probably the bright outer rim of the inner ring. Two dusky belts south

and one north, the poles dusky. At $5^h 50^m$ the equatorial bright belt seemed rather brighter than the equally broad bright space on the other side of the dark band, whose breadth was the same also. At $5^h 58^m$ A.M. I perceived that the north edge of the dark band had a deep orange tint, and there seemed to be a short semi-elliptic bright segment cut out of this orange border at about its middle. The orange tint is that of *Saturn* seen through the crape ring. Both ansæ continued to be easily visible till $6^h 5^m$ A.M.; they became faint at $6^h 9^m$, and flashed out occasionally at $6^h 13^m$, as did also *Rhea* and *Tethys*. The preceding ansa was the more easily caught sight of at $6^h 20^m$ A.M., when *Titan* was only just perceptible, a light haze now coming up. At about $6^h 0^m$ A.M. I had perceived bright projections, one on each ansa; that on the preceding ansa, about halfway, was possibly due to the atmosphere of the ring, that on the following ansa, near its E. end, may have been *Mimas*.

November 3, $5^h 25^m$ A.M.—The blue ansa west of *Saturn* seen through light cloud, *Tethys* E., *Titan* W. At $5^h 28^m$ very good definition (with power 180), *Mimas*, *Rhea*, *Dione* closely followed the E. end of the ring, the blue ansa east being very plainly seen also. (*Enceladus* too close to *Saturn* to be detected.)

At $5^h 38^m$ both ansæ visible. At $5^h 48^m$ both ansæ alternately visible through thin passing cloud. At $5^h 53^m$ I noticed the colour of the equatorial belt to be yellow, the rest of *Saturn* pale white, except where dark band and dusky belt S. and N. cross it, the N. belt very faint. The dark band is again seen to be orange tinted on its N. edge. *Dione* and *Rhea* could be seen at $5^h 59^m$; but at $6^h 11^m$, in spite of the light haze, both ansæ were more easily visible than those two satellites. The preceding ansa, the south dusky belt, dark band, and bright equatorial belt remained visible up to $6^h 31^m$, when *Titan* could be only glimpsed through the haze.

From these circumstances, I am confident that if the blue ansæ had been visible to any telescope at all comparable with that in my charge on the morning of October 31, I should have seen them. It has been already stated that they came into view immediately on the morning of November 2. I conclude, therefore, that the plane of *Saturn's* rings probably passed through the Sun's centre on November 1, at about 6 A.M., or possibly one hour, or two hours at most, earlier. From the heliocentric longitude ($172^\circ 6' 17''.0$) and heliocentric latitude ($2^\circ 8' 38''.3$ N.) of *Saturn*, October 31, 18^h G.M.T. (astronomical time), and with an inclination $28^\circ 10' 11''.4$ of the ring plane to the ecliptic for 1891 $\frac{1}{2}$, which is derived from Bessel's formula (with the values of δn , δi and m , stated by Professor J. A. C. Oudemans to be the correct solution of Bessel's own equations (in *Monthly Notices of the Royal Astronomical Society*, December, 1888, page 57), I infer that the node of *Saturn's* rings on the ecliptic, when the ring-plane passed

through the Sun, was in longitude $168^{\circ} 5' 45''.7$.^{*} I may mention that Professor Oudemans has kindly informed me, by letter dated November 6, that with his $9\frac{1}{2}$ -inch refractor, at Utrecht, he had a clear view of *Saturn* on the Friday morning and saw no ring, that Saturday (October 31) was overcast, and on Sunday morning he once, for a moment only, at $5^h 10^m$ A.M. (G.M.T), fancied he saw the ring through passing clouds, but Monday again was overcast, and he did not see the ansæ until Tuesday morning. His observations confirm the inference I had reported to him as derivable from my own views of *Saturn* on the mornings of Saturday, October 31, and Monday, November 2.

Murston Rectory, Sittingbourne :
1891 November 9.

Comparative Photographic Spectra of the Sun and the Metals.
Series I. and II. By F. McClean, M.A.

I wish to lay before the Society two series of photographic spectra, in which the spectra of the Sun and of the fifteen metals enumerated are mounted in parallel sections, in order to facilitate their comparison and the identification of their lines. The spectra extend from wave-length 3,800 to wave-length 5,750 tenth metres, or from above (H) to near (D).

Series I. contains spectra of the Sun, iron, platinum, iridium, osmium, palladium, rhodium, ruthenium, gold and silver. The last eight constitute the platinum group of metals.

Series II. contains the spectra of the Sun, iron, manganese, cobalt, nickel, chromium, aluminium and copper. These seven metals constitute the iron-copper group.

Each series consists of six sections, corresponding to six sections of Ångström's chart.

The broad lines and bands which run uniformly across all the metallic spectra are due to the air. This spectrum is always present when the induction spark is taken between metal electrodes in the air. Its lines and bands are coarser, relatively to the other lines, than in the original negative. This is due to their prominence and consequent over-exposure in the negative. A special series of photographs are requisite to obtain the air spectrum relatively at its best, but as it is shown here it will bear comparison with the existing maps of it.

Before the true spectra of the metals can be arrived at, it is necessary to further eliminate the lines due to various impurities in the specimens of the metals employed as electrodes. Iron

^{*} Bessel's equations, corrected as above, give $168^{\circ} 4' 16''.1$ as the longitude of the node for 1891 $\frac{1}{2}$. The difference seems probably attributable more to the unknown nutation of the ring, caused by all the satellites, than to the small disturbing precessional influence exercised by the Sun and *Iapetus*.

appears in the spectrum of aluminium, and to a less degree in other spectra. Calcium is almost universally present, and becomes especially prominent throughout Section I. Its principal lines run with varying strength across nearly every spectrum, and coincide with marked groups of lines in the solar spectrum. The calcium spectrum appears most strongly in osmium and cobalt. The principal barium lines are also present in osmium, and its complete spectrum is no doubt present in Section I.

The beautiful fluting of lines in Section IV. of the aluminium spectrum, is attributed by Thalén to the oxide of aluminium formed in the aureole of the induction spark. The similar well-defined but less-marked fluting which occurs in many of the spectra in Section I. must be due to one of the constituents of the air. It cannot be due to calcium, as it is prominent in metals where calcium is absent.

The spectra of iridium, ruthenium, and rhodium, are, I believe, practically new work, and so I think are some of the other spectra, to the extent of Section I. and part of Section II.

The specimens of the metals of the platinum group which have been employed, were all obtained from Messrs. Johnson and Mathey, and were nominally pure.

The specimens of the metals of the iron group and most of the other specimens prepared for the further prosecution of the work have been obtained from Messrs. Hopkin and Williams. Some are nominally pure, but others, including aluminium, nickel, and cobalt, do not seem procurable in a pure state.

The identification of iron lines in the solar spectrum is, of course, evident. The identification of chromium, manganese, cobalt and nickel with weaker lines, can readily be made. It is impossible, however, to obtain any complete results from these two series of photographs alone. Photographs of the spectra of all the common oxidisable metals, and particularly of calcium, barium, magnesium and titanium, are first required; also duplicates of the present photographs are necessary in order to make direct comparisons between the separate spectra. The mounted photographs are being reproduced by the Direct Photo-Engraving Company. Specimens of four of the prints will be found along with the originals. The white lines unfortunately become a little coarser in the process.

Mean Areas and Heliographic Latitudes of Sun-spots in the year 1890, deduced from Photographs taken at Greenwich, at Dehra Dûn (India), and in Mauritius.

(Communicated by the Astronomer Royal.)

The results here given are in continuation of those printed in the *Monthly Notices*, vol. l. p. 378, and are deduced from the measurements of solar photographs taken at the Royal Observatory, Greenwich, at Dehra Dûn, India, and at the Royal Alfred Observatory, Mauritius.

Table I. gives the mean daily areas of umbræ, whole spots, and faculæ, for each synodic rotation of the Sun in 1890; and Table II. gives the same particulars for the entire year. The areas are given in two forms: First, projected areas, that is to say, as seen and measured on the photographs, these being expressed in millionths of the Sun's apparent disc; and next, areas as corrected for foreshortening, the areas in this case being expressed in millionths of the Sun's visible hemisphere. Table III. exhibits for each rotation in 1890 the mean daily area of whole spots, and the mean heliographic latitude of the spotted area, for spots north and for spots south of the equator, together with the mean heliographic latitude of the entire spotted area, and the mean distance from the equator of all spots; and Table IV. gives the same information for the year as a whole.

TABLE I.

No. of Rotation.	Date of Commencement of each Rotation.	No. of Days on which Photographs were taken.	Mean of Daily Areas.					
			Umbræ.	Projected.		Corrected for Foreshortening.		
				Whole Spots.	Faculæ.	Umbræ.	Whole Spots.	Faculæ.
485	1890 Jan. 1 ^d 19	28	8.4	47.8	180	7.2	45.3	213
486	Jan. 28.54	27	0.8	3.3	54.0	0.5	2.2	71.8
487	Feb. 24.87	26	16.9	94.1	229	14.1	83.7	264
488	Mar. 24.19	28	0.8	8.7	45.9	0.5	5.5	52.1
489	Apr. 20.47	27	4.6	33.3	81.1	3.0	23.0	93.5
490	May 17.70	27	3.7	22.8	130	2.9	17.1	152
491	June 13.90	27	13.3	78.2	140	11.0	68.4	155
492	July 11.10	26	24.9	150	238	19.2	115	296
493	Aug. 7.31	28	59.0	394	142	36.3	241	156
494	Sept. 3.56	26	26.3	176	489	22.6	160	536
495	Sept. 30.83	27	47.7	316	604	36.2	247	598
496	Oct. 28.12	28	18.1	104	626	16.1	96.9	658
497	Nov. 24.43	26	60.9	344	520	38.4	224	644

TABLE II.

Year.	No. of Days on which Photographs were taken.	Umbrae.	Projected. Whole Spots.	Mean of Daily Areas.		
				Faculae.	Corrected for Foreshortening.	
					Umbrae.	Whole Spots. Faculae.
1890	361	21'3	133	273	15'5	99'4 304

The rotations in Table I. and Table III. are numbered in continuation of Carrington's series (Observations of Solar Spots, made at Redhill, by R. C. Carrington, F.R.S.), No. 1 being the rotation commencing 1853 November 9. The assumed prime meridian is that which passed through the ascending node at mean noon on 1854 January 1, and the assumed period of the Sun's sidereal rotation is 25'38 days. The dates of the commencement of the rotations are given in Greenwich civil time, reckoning from mean midnight.

TABLE III.

No. of Rotation.	Date of Commencement of each Rotation.	No. of Days on which Photographs were taken.	Spots North of the Equator.		Spots South of the Equator.		Mean Heliographic Latitude of Entire Spotted Area.	Mean Distance from Equator of all Spots.
			Mean Daily Areas.	Mean Heliographic Latitude.	Mean Daily Areas.	Mean Heliographic Latitude.		
485	1890 Jan. 1 ^d 1'19	28	34'4	22'54	10'9	10'72	+ 14'58	19'71
486	Jan. 28'54	27	2'2	24'47	0'0	...	+ 24'47	24'47
487	Feb. 24'87	26	82'9	32'76	0'8	30'43	+ 32'15	32'74
488	Mar. 24'19	28	2'6	25'55	3'0	26'28	- 2'21	25'94
489	Apr. 20'47	27	8'3	24'37	14'7	28'02	- 9'04	26'70
490	May 17'70	27	2'0	20'97	15'1	26'79	- 21'30	26'12
491	June 13'90	27	0'0	...	68'4	23'58	- 23'58	23'58
492	July 11'10	26	32'0	18'28	83'0	11'55	- 3'22	13'39
493	Aug. 7'31	28	231	21'20	9'3	19'67	+ 19'66	21'17
494	Sept. 3'56	26	88'8	21'39	70'9	21'33	+ 2'43	21'37
495	Sept. 30'83	27	4'0	20'47	243	23'08	- 22'37	23'03
496	Oct. 28'12	28	27'4	19'49	69'5	23'94	- 11'67	22'68
497	Nov. 24'43	26	190	20'10	33'8	27'81	+ 12'87	21'26

TABLE IV.

Year.	No. of Days on which Photographs were taken.	Spots North of the Equator.		Spots South of the Equator.		Mean Heliographic Latitude of Entire Spotted Area.	Mean Distance from Equator of all Spots.
		Mean of Daily Areas.	Mean Heliographic Latitude.	Mean of Daily Areas.	Mean Heliographic Latitude.		
1890	361	53'1	22'20	46'3	21'75	+ 1'73	21'99

The above tables, when compared with those given on pp. 378 and 379 in volume I., show clearly that the Sun-spot minimum is already past, a conclusion which is abundantly con-

firmed by the rapid increase in the numbers and areas of spots and faculæ seen during the present year, 1891. The tendency for spots to form in high latitudes, which was noticed towards the end of 1889, continued throughout 1890, the mean distance from the equator of all spots in 1890 being $21^{\circ}99$, as compared with $11^{\circ}61$ in 1889 and $7^{\circ}39$ in 1888. This difference is due chiefly to the nearly total disappearance of spots from the immediate neighbourhood of the equator in 1890, for only one considerable group during the entire year, that of July 22—August 1 had a lower latitude than 18° ; at the same time the spots of the new series, that is to say, of the high-latitude zones, north or south, were much more numerous than in 1889 and maintained as great a distance from the equator.

The northern hemisphere showed a slight preponderance over the southern as to spot activity in 1890, for the first time since 1881.

Observations of Wolf's Periodical Comet (b 1891) made at the Royal Observatory, Greenwich.
(Communicated by the Astronomer Royal.)

The observations were made with the East, or Sheepshanks, Equatorial, aperture 6·7 inches, by taking transits over two cross wires at right angles to each other, and each inclined 45° to the parallel of declination. Magnifying power about 200 on October 2, 3, 4, and 55 on October 9, 12, and 14.

Greenwich Mean Solar Time.	Observer.	* RA.		Corr. for Parallax.	Corr. for Refraction.	* N.P.D.		Corr. for Parallax.	Corr. for Refraction.	No. of Comps.		Apparent R.A.		Tabular R.A.	Apparent N.P.D.	Comp. Star.
		m	s	s	s	'	"	s	s	h	m	s	s	h	m	
Oct. 2 11 8 41	T.	+0	37·0	-0·4	0·0	-13	23·2	-7·3	-0·3	1				4 28 13	76 41·7	a
11 17 13	"	+2	49·9	-0·4	0·0	-10	39·0	-7·3	-0·1	6		4 28 16·4		4 28 13	76 41·7	b
11 23 38	"	+2	1·3	-0·4	0·0	-7	7·2	-7·2	0·0	4				4 28 14	76 41·8	c
3 11 30 36	A.C.	-0	13·6	-0·4	0·0	+2	25·7	-7·3	0·0	4				4 29 20	77 11·7	d
11 33 56	"	+1	39·5	-0·4	0·0	+13	31·0	-7·2	+0·2	3		4 29 20·5		4 29 20	77 11·8	e
4 10 41 47	H.	-1	41·9	-0·4	0·0	-1	20·5	-7·6	0·0	6		4 30 23·8		4 30 21	77 40·7	f
10 53 33	"	-0	57·6	-0·4	0·0	-2	44·9	-7·5	0·0	3				4 30 21	77 40·9	g
9 11 27 34	T.	+5	19·0	-0·4	0·0	+13	40·2	-7·6	+0·3	2		4 34 57·0		4 34 56	80 16·2	h
11 27 34	"	+5	14·5	-0·4	0·0	+13	3·3	-7·6	+0·3	2		4 34 56·1		4 34 56	80 16·2	k
12 10 42 46	H.	+1	48·0	-0·4	0·0	-3	55·1	-8·0	-0·1	6		4 37 7·2		4 37 3	81 51·2	l
10 51 16	"	+1	26·1	-0·4	0·0	-0	35·3	-8·0	0·0	2				4 37 4	81 51·4	m
11 6 8	"	-0	34·1	-0·4	0·0	-3	29·8	-7·9	0·0	2				4 37 4	81 51·7	n
14 11 10 35	L.	+1	17·3	-0·4	0·0	+14	30·6	-8·0	+0·4	2		4 38 19·6		4 38 16	82 56·6	o
11 10 35	"	+0	33·6	-0·4	0·0	+12	55·7	-8·0	+0·3	2				4 38 16	82 56·6	p

Assumed Mean Places of Comparison Stars.

	Star's Name.	R.A. 1891°.		N.P.D. 1891°.		Authority.
		h	m	°	' "	
<i>a</i>	Anonymous					
<i>b</i>	W.B. (1) IV. 482	4	25	24	53	Weisse's Bessel (1)
<i>c</i>	B.D. + 13°, 694	4	26	13	51	Bonn Observations, vol. iii.
<i>d</i>	Anonymous					
<i>e</i>	W.B. (1) IV. 531	4	27	39	27	Weisse's Bessel (1), with proper motion, - 0".27 in N.P.D., deduced from comparison with Armagh Catalogue I. and Sj.
<i>f</i>	90 Tauri	4	32	3	86	Greenwich 10-Year Catalogue, 1880.
<i>g</i>	B.D. + 12°, 616	4	31	20	44	Bonn Observations, vol. iii.
<i>h</i>	Armagh, I. 980	4	29	36	01	Armagh Catalogue, 1840; R.A. from Weisse's Bessel (1)
<i>k</i>	88 Tauri	4	29	39	67	Armagh Catalogue, 1840
<i>l</i>	W.B. (1) IV. 725	4	35	17	12	Weisse's Bessel (1)
<i>m</i>	B.D. + 8°, 737	4	35	40	54	Bonn Observations, vol. iii.
<i>n</i>	B.D. + 7°, 700	4	37	43	56	Bonn Observations, vol. iii.
<i>o</i>	W.B. (1) IV. 760	4	37	0	28	Weisse's Bessel (1)
<i>p</i>	B.D. + 7°, 701	4	37	42	44	Bonn Observations, vol. iii.

Star *e* was observed with the Transit Circle on November 7, and a preliminary reduction gives R.A. 1891° 4^h 27^m 39^s.83, N.P.D. 1891° 76° 58' 41".5. The observations are corrected for refraction and parallax; in computing the latter log Δ has been taken from Berberich's Ephemeris, the values used being: October 2, 9'9310, October 3, 9'9287, October 4, 9'9268, October 9, 9'9177, October 12, 9'9127, October 14, 9'9097. The tabular places given are also interpolated from Berberich's Ephemeris.

The initials T., L., H., A.C., are those of Mr. Thackeray, Mr. Lewis, Mr. Hollis, and Mr. Crommelin respectively.

On the Orbit of Spitaler's Comet (VII. 1890).
By Lieut.-General Tennant, C.I.E., R.E., F.R.S.

In No. 3010 of the *Ast. Nach.*, Professor Spitaler expressed an opinion that at its last passage through its descending node this comet passed so near *Jupiter* that its orbit must have been entirely changed. Since then Dr. Hind has made a communication to the Academy of Sciences at Paris, pointing out that the best orbit of the comet did not justify this conclusion.

Soon after seeing Professor Spitaler's remark, I collected such information as was available about the comet, and resolved to examine the question. As an American orbit differed very sensibly from that used by Spitaler, I computed a fresh one from the Vienna Observations of 1890 November 16 and December 13, and that made at the Lick Observatory on 1891 January 12.

From these I deduced the following elements:—

Perihelion passage 1890 October 26^h 11^m 18^s 74 = 2^h 56^m 59^s G.M.T.

$$\left. \begin{array}{l} \pi = 58^{\circ} 15' 31'' 23 \\ \Omega = 45^{\circ} 08' 01'' 32 \\ i = 12^{\circ} 51' 27'' 69 \end{array} \right\} \text{Equinox of 1891.0}$$

$$\phi = 28^{\circ} 12' 45'' 58$$

$$\mu = 554' 2197 \left. \begin{array}{l} \log a = 0.5375498 \end{array} \right\} \text{Period} = 2338^d.46 = 6.4022 \text{ years}$$

Comparing these with the whole of the observations I could find, the result was a very general agreement, showing that the accuracy was far greater than usual in comet observations. The observation at Lick on 1890 December 11 was found to have the time too late by two hours, and this correction was kindly verified by the observer, Mr. Barnard. The whole number of observations was very small, but I deduced the following errors of the Ephemeris founded on the above elements:—

Paris M.T.	$\Delta \alpha \cos \delta$	$\Delta \delta$
1890 Nov. 16.644	+ 1'' 1	- 0'' 7
Dec. 6.247	- 1' 5	- 0' 3
Dec. 10.558	- 1' 1	- 3' 2
Jan. 8.074	- 4' 5	+ 2' 2
Jan. 12.131	+ 0' 1	- 1' 0

On forming equations of condition for correcting the elements referred to the equator, it was evident, as might have been expected, that a change of π could be almost entirely compensated by one of the time of Perihelion Passage; and so, that a change in the Major Axis would be compensated by one in the eccentricity. After making the equations homologous, I adopted the following plan:—

For r and x the unknowns, which are multiples of the corrections required to μ and ϕ , I substituted r' and x' , such that $r' = r + x$ and $x' = r - x$; similarly for y and z multiples of the corrections to τ and π' were substituted $y' = y + z$ and $z' = y - z$.

Of course the coefficients of x' and z' were too small to give any trustworthy determinations; but, after forming the normal equations, it was found that when the unknowns, which were multiples of the corrections to the inclination and node, were eliminated the coefficients of x' and y' were both very small, and these quantities also were indeterminate. Four then of the elements are subject to very large corrections.

Eventually I found the following corrections:—

$$\begin{aligned}\Delta i &= +1''.91 + 378.5d\mu - 1.434d\phi - 32923d\tau + 4.151d\pi' \\ \Delta \Omega &= +7.10 + 2081.4d\mu - 1.424d\phi - 23416d\tau + 14.192d\pi',\end{aligned}$$

and π requires the small correction

$$\Delta \pi = -0''.53 - 142.3d\mu + 0.174d\phi + 1844d\tau - 0.107d\pi',$$

where π' is the longitude of Perihelion referred to the equator.

By substituting the numerical parts of the values determined for the two retained unknowns in the equations of condition, I found

Sum of errors before correction in R	=	- 6''.1	in Dec.	- 3''0
„ after „ „	+	0.2	„	0.0
Sum of squares before „ „		24.93	„	16.66
„ after „ „		15.79	„	12.94

The corrected elements then are subject to the uncertainty resulting from corrections to π' and the other three elements.

$$\left. \begin{aligned}\pi &= 58^{\circ} 13' 50.69'' \\ \Omega &= 45^{\circ} 08' 08.42'' \\ i &= 12^{\circ} 51' 29.60''\end{aligned} \right\} \text{Equinox of 1891.0,}$$

the others being unchanged.

With these elements there can be no very near approach to *Jupiter* at the time supposed by Dr. Spitaler. Nor is it readily conceivable that the observations will admit such changes as would make a near approach possible. It is remarkable that, where the conditions have been so unfavourable, successive computers have arrived at orbits so near each other as those published.

Measures of Planetary Nebulæ with the 36-inch Equatoreal of the Lick Observatory. By S. W. Burnham, M.A.

During the progress of my regular double star work with the 36-inch equatoreal, I have occasionally examined some of the more interesting nebulæ, and incidentally a few of the Herschel planetary nebulæ. It occurred to me that objects of the latter class would be specially suitable for careful micrometrical measures for the purpose of determining, now or hereafter, whether they have any proper motion in space. I assumed that some of the many observers of nebulæ had already done this for at least the brighter nebulæ of this class, or those where the central stars were bright enough to bring them within the reach of ordinary instruments. I was surprised to find, upon looking over many of the works of the leading observers, that very little, almost nothing, had been done in this field; and I determined, therefore, to measure all the objects of this class when it could be done without seriously interfering with the regular micrometer work on double stars. In the selection of objects classed as planetary nebulæ, I have relied, of course, upon Dreyer's General Catalogue. After an examination of a few of the prominent examples, it is not difficult to say whether or not a doubtful object belongs to the planetary class, since it is entirely a matter of appearance in the telescope, and has nothing to do with the nature of the nebulæ as shown by the spectroscope or otherwise. A central star is usually found in these nebulæ. This is so generally the case as to suggest that as the criterion for classification. Some of these stars are very faint, and can only be seen with a large aperture, and, in a few instances, the large object-glass furnishes none too much light for their accurate measurement with the micrometer. As will be seen from the observations, I have found but two or three nebulæ, which could be otherwise described as of the planetary class, where the central star is wanting. From the wide range of these stars in magnitude, it is fair to infer that the missing stars might be seen with a telescope of still greater light-power. One of these is very far south, and too low in this latitude for any very faint star.

I have also examined Nos. 934, 2440, 2452, 4107, 5144, and 6210 of Dreyer's General Catalogue, and found them more or less lacking in the characteristics of planetary nebulæ. They belong to a much larger and less interesting class of objects, which would be briefly described as small circular patches of nebulosity. Many of the more recently discovered nebulæ, though very much fainter, and usually smaller, are similar in a general way. I have also looked at a number of the so-called "stellar" nebulæ, discovered by Pickering, Swift, and others. These are all, so far as I have examined them, very small, bright, round nebulæ, which in a small instrument would resemble stars slightly out of focus, but do not appear to come within the planetary class.

Various powers have been used in studying these central stars, and particularly the brighter ones. In no instance has any one of these stars presented under any power any peculiar appearance. So far as it can be determined in this way, they all appear to be true stars, differing in no sense from the comparison stars. Many of the nights on which these measures were made were of the best quality, and any nebulous or other unusual appearance should have been apparent if it really exists.

I have not attempted to give any detailed description of these objects, in the first place because it was foreign to the special purpose in view, and secondly because verbal descriptions, like most of the drawings, have at this time little scientific value, and particularly so far as the question of change or motion is concerned. Certainly no one would predicate any change upon evidence of this kind. Skilled observers, even with instruments of about the same power, differ greatly, and it is impossible to eliminate the real from the imaginary. I have, therefore, limited my observations to actual measures with the micrometer, the accuracy of which can be tested at any time.

I think there can be no doubt that these central stars are in some way associated with the nebulae themselves, and that any change in the positions of these stars will be accompanied by a corresponding drift in space of the nebulae. Of the thousands of nebulae now known, these examples in the planetary class, with a few exceptions possibly among very minute nebulae, are the only ones where any proper motion could be detected within any reasonable time. For this reason there is no reliable evidence yet of the change in position of any nebula in the heavens. There is no apparent reason why the nebulae should not be distributed in space in the same manner as the stars, and with the same varying distances from our system. If this is so, the nebulae should be drifting in space with proper motions analogous to those of the stars. A re-measurement of these objects a few years from now will detect at once even a small annual variation. Some of them can be measured with much smaller instruments than the one now used. In some instances the comparison star is very faint, but I have endeavoured to select the best star, taking the magnitude and distance both into account. Should any relative change be shown hereafter, it will be easy to determine to which of the stars it belongs.

In the observations which follow, I have used Dreyer's number and place. In nearly every instance the measures were made with a power of 350, the higher eye-pieces having too small a field for many of the distances. The measures are made by double distances, except in the single instance noted, and of course with a bright-wire illumination, which interferes in no way with the visibility of the faintest object.

Barnard.

$$\begin{array}{l} \text{R.A. } 3^{\text{h}} 38^{\text{m}} 34^{\text{s}} \\ \text{Decl. } +34^{\circ} 37' \cdot 6 \end{array}$$

This planetary nebula was discovered by Barnard in December last while observing Zona's Comet (*Ast. Nach.* 3017). It is a fine object in the telescope, and perfectly planetary in general appearance. On one occasion I suspected a central star or a very small nucleus, but this has not been verified. It is slightly elliptical in a north and south direction. A rough setting of the wires on two nights gave, with a power of 1000, $10'' \cdot 0$ as the diameter of the nebula in this direction. Barnard re-measured the diameter December 10, 1890, and obtained $8'' \cdot 5$.

The nearest catalogue star is *D.M.* +34°, 732, called 9·0 *m* by Argelander:

Nebula and D.M. +34°, 732.

1891·689	119°·6	204°·50 . . . 8
·692	119°·5	203°·74 . . . 8·3
1891·69	119°·5	204°·12

These are single distances. The measures give for the difference in R.A. $14^{\text{s}} \cdot 4$, and for the difference in Decl. $100'' \cdot 7$. In December, 1890, Barnard observed these differences directly, using the 12-inch refractor, and obtained $14^{\text{s}} \cdot 4$ and $102'' \cdot 0$ for the corresponding values.

I have also measured the nearest of the two faint stars referred to in *Ast. Nach.* 3017, from the centre of the nebula, with the following result:—

Nebula and 13 m. Star Preceding.

1891·689	288°·4	21°·79 . . . 13
·692	287°·8	21°·78 . . . 13
1891·69	288°·1	21°·78

The other star, 14 *m*, is $33''$ from the nebula, in the direction of 347° . The magnitude of the nebula was estimated by Barnard as 10 *m*. It is easily found from the sketch of the field given in *Ast. Nach.* 3017.

Applying the differences obtained above to the *D.M.* place of the comparison star, we have for the nebula (1860) the place given above.

No. 1501.

R.A. $3^h 54^m 59^s$ }
 Decl. $+60^\circ 32'$ }

1890·775	193·8	90·97	12·5 . . . 12·7
1890·777	193·8	91·03	13·5 . . . 13·7
1890·77	193·8	91·00	13·0 . . . 13·2

This is one of the Herschel planetary nebulae. The central star is brighter than the nearest available comparison star.

There are two observations of these stars with the Rosse reflector, the second of which is probably by Copeland :

1867·961	195·7	91·5
1873·870	192·9	89·9

No. 1514.

R.A. $4^h 0^m 30^s$ }
 Decl. $+30^\circ 24'$ }

1891·657	357·4	69·94	8·6 . . . 14
·689	357·9	70·11	8·6 . . . 14
·692	357·2	70·18	8·6 . . . 14
1891·68	357·5	70·08	8·6 . . . 14

The small star used for comparison is in, or near, the edge of the nebula. The diameter of the nebula is about $126''$. The small star does not appear to have been noticed before. Herschel speaks of a "faint star following," and in another observation, "star suspected *n. p.*," but no distance is given. In the drawing by Rosse (*Phil. Trans.* 1861) a small star is shown in the direction of 60° or 70° , and distant about one diameter of the nebula from its edge. This nebula is not described as planetary in Dreyer. Mr. Barnard called my attention to it as probably belonging to the planetary class; and it certainly possesses the general characteristics. The surface, however, is not uniform, but broken and mottled.

No. 1535.

R.A. $4^h 7^m 44^s$ }
 Decl. $-13^\circ 6'$ }

1890·760	257·3	119·42	11·5 . . . 12
1890·775	257·0	120·21	11·0 . . . 11·5
1890·785	257·1	119·69	11 . . . 12
1890·77	257·1	119·77	11·2 . . . 11·8

Besides the central star, there are other fainter stars within the nebula. The most prominent of these is near the northern edge of the circular disc. I have measured this from the central star as follows:—

1890·760	323°1	16''47 . . .	15
1890·775	324·6	16·26 . . .	14·5
1890·785	324·7	15·79 . . .	14
1890·77	324·1	16·17 . . .	14·5

This nebula is H IV. 26. It has been drawn by D'Arrest (*Instrumentum Magnum Æquatorium*, 1861); and by Lassell (*Memoirs R.A.S.*, vols. xxiii. and xxxvi.). The 14·5 m. star does not seem to have been seen by these observers.

There are two measures of the distant star by Copeland at Parsonstown.

1873·003	256°7	122''9 . . .	14 ^m
1873·041	256·7	121·2 . . .	13 ^m

No. 2022.

R.A. 5^h 34^m 26^s }
Decl. +9° 1' }

1890·802	192°6	95''60	14·5 . . .	13·5
1890·840	192·2	95·34	15 . . .	14
1890·82	192·4	95·47	14·7 . . .	13·7

There is no star in the middle of this nebula, but there is a very faint one on the *s.p.* edge, and that is the one measured. The nearest outside star is *n.f.*, and about one diameter of the nebula distant. With reference to the nebulous disc Lassell says: "Some bright patches or nodules seem to exist in it, but nothing more can be made out." There are drawings by D'Arrest and Lassell in the volumes last cited, and also by Secchi (*Mem. Coll. Rom.* 1852-5).

No. 2392.

R.A. 7^h 20^m 53^s }
Decl. +21° 12' }

1890·879	3°0	99''62	9·0 . . .	8·2
1890·882	2·9	99·74	8·7 . . .	8·2
1890·88	3·0	99·68	8·9 . . .	8·2

One of the most beautiful objects of the kind in the heavens. The central star is round and sharp with all powers. A measure of the diameter of the bright inner disc in the direction of the outside comparison star gave $19''\cdot 0$; and for the diameter of the whole disc in the same direction $44''\cdot 7$ (1890·88). There are drawings of this nebula by Lassell (*Mems. R.A.S.* xxiii. and xxxvi.); D'Arrest (*Observations of Nebulæ*, 1867); Rosse (*Phil. Trans.* 1850); and Secchi (*Mem. Coll. Rom.* 1852-55). Lassell speaks of the comparison star as being nebulous. I did not notice any peculiarity in the appearance of this star. Schönfeld (in 1862·19) made the difference in R.A. $0^s\cdot 20$ and in Decl. $100''\cdot 4$. These stars have been measured directly as follows:—

1853·20	$2^{\circ}6$	$100''12$	OZ	4^n
1864·98	$2^{\circ}4$	$100''16$	Knott	4^n
1873·70	$2^{\circ}9$	$98''0$	Copeland	3^n

No. 2438.

R.A. $7^h\ 35^m\ 26^s$ }
Decl. — $14^{\circ}\ 25'$ }

Central Star and Star sf.

1890·939	$127^{\circ}1$	$49''88$	12 . . .	$11^{\circ}5$
1891·151	$127^{\circ}6$	$49''56$	12 . . .	$10^{\circ}7$
1891·04	$127^{\circ}3$	$49''72$	12 . . .	$11^{\circ}1$

These stars were measured at Parsonstown.

1873·006	$128^{\circ}6$	$48''7$	. . .	Copeland 1^n
1876·123	$129^{\circ}6$	$50''0$	16 . . .	Dreyer 1^n

Central Star and Star in Nebula.

1890·939	$209^{\circ}0$	$15''10$	. . .	$14^{\circ}5$
1891·151	$210^{\circ}7$	$15''27$	. . .	$13^{\circ}5$
1891·04	$209^{\circ}8$	$15''18$	. . .	$14^{\circ}0$

The last measures connect the central star with a faint star in the *s.p.* side of the ring. This is probably the star shown in Rosse's drawing, and must be the one shown in Lassell's drawing, although the position-angle is erroneous if the drawing is to be looked at in the usual way. The outside diameter of the nebula

is $63''\cdot9$. There are drawings by Rosse (*Phil. Trans.* 1850); Lassell (*Mems. R.A.S.* xxiii.); and Secchi (*Mem. Coll. Rom.* 1852-5). Copeland has a single measure of the last-named star.

1873°063 210°·8 17''·4 13-14 . . . 16

No. 2452.

R.A. $7^h 41^m 47^s$
Decl. $-27^\circ 0'$ }

Not planetary. There are two nuclei, giving it a sort of dumb-bell appearance.

No. 3242.

R.A. $10^h 18^m 2^s$
Decl. $-17^\circ 56'$ }

1891°241	173°·1	155''·11	12 . . . 10°5
·244	173°·0	155'·47	11 . . . 10°5
·246	173°·2	155'·98	11 . . . 10°5
1891°24	173°·1	155'·52	11·3 . . . 10°5

I have made the following measures of this interesting object :—

Direction of the longer axis of the Ellipse	324°·8
Longer diameter of the whole Ellipse	... 42''·4
Shorter " " "	... 38'·3
Longer diameter of inside ring	... 23'·2
Shorter " " " "	... 17°·0

This nebula has been drawn by Herschel (*Cape Observations*); Lassell (*Mems. R.A.S.* xxiii. and xxxvi.); Secchi (*Mem. Coll. Rom.* 1852-5); and Rosse (*Trans. R. Dublin Soc. II.*). There is a single observation of these stars by Searle (*Annals Harvard Obs.* xiii.) giving $172^\circ\cdot5 : 154''\cdot64$ (1868·06). The comparison star is called 13 *m*. There is also a single measure of Copeland, $173^\circ\cdot9 : 155''\cdot2$ (1874·18).

No. 3587.

R.A. $11^{\text{h}} 6^{\text{m}} 40^{\text{s}}$ }
 Decl. $+55^{\circ} 47'$ }

1891·239	25°3	156''15	13·5 . . .	10
·241	24·5	156·49	14·5 . . .	10·5
·244	24·6	156·79	14·5 . . .	11
1891·24	24·8	156·48	14·2 . . .	10·5

This has been drawn by Rosse (*Phil. Trans.* 1833, 1850).

No. 4107.

R.A. $11^{\text{h}} 59^{\text{m}} 35^{\text{s}}$ }
 Decl. $+11^{\circ} 23'$ }

Not planetary, but it is brighter in the middle, and extended in the direction of 115° . In Dreyer it is described as having a star 10–11 *m.*, south following. There is nothing in that place, but there is a star of that magnitude north preceding.

No. 6369.

R. A. $17^{\text{h}} 20^{\text{m}} 49^{\text{s}}$ }
 Decl. $-23^{\circ} 38'$ }

1891·594	58°8	90''52	14 . . .	13·5
·597	46·7	90·30	15 . . .	13·8
1891·59	57·7	90·41	14·5 . . .	13·7

This is an annular nebula, and very much like the well-known example in *Lyra*, except in brightness. The longer axis is in the direction of 33° , and the extreme diameter on that line is 31''. Herschel has a drawing in Cape Observations. I am not aware of the central star having been seen before.

No. 6543.

R.A. $17^{\text{h}} 58^{\text{m}} 36^{\text{s}}$ }
 Decl. $+66^{\circ} 38'$ }

1891·392	292°3	163''34		
·395	292·4	163·14	9·5 . . .	9·0
·397	292·4	163·18	9·7 . . .	8·8
·416	292·4	163·28	9·5 . . .	8·7
1891·40	292·4	163·24	9·6 . . .	8·8

This is the well-known planetary nebula in *Draco*. It has been more frequently observed than any other object of this class with the exception of the ring nebula in *Lyra*. The comparison star is D.M. +66°, 1065. The only direct measures of these stars which I have found are two single observations with the Rosse reflector by Dreyer as follows:—

1873·709	290°1	161°6
1873·711	291°2	162°8

In 1871-2 Brunnnow used the same stars in an attempt to measure the parallax of the nebula, but measured the difference of declination only (*Dunsink Observations III.*). From a large number of measures he found this difference to be 62''·90. Later, Bredichin, in a similar work, used the same stars and method of observation (*Annals Obs. Moscow III.*), but I have not seen this volume and do not know what result he obtained. Schönfeld (1861·64) obtained 63''·4; and Schultz in 1865, as a mean of five rather discordant measures, 63''·0. These different results apparently indicate a movement on the part of one or the other of the stars, or that at least some of the observations are of very doubtful value; but the important fact must be considered that the central star was not really seen at all by most of the observers, and that the measures were made from the estimated centre of the nebula. Schultz used the "geometrical centre" of the nebula, and Schönfeld evidently did not see the star. At Parsonstown, where the direct measures were made, it was noted "no certain indication of a central star"; and therefore these observations, like those giving the difference in declination, cannot be compared with the late measures for the purpose of determining whether or not there has been any relative change. The Dunsink measures, however, seem to be on a different footing in this respect, for Brunnnow says that the nebula "has in the centre a well-defined point resembling a star of the eleventh magnitude. I have compared this point in declination with a star to the north of the tenth magnitude," etc. Evidently the star was not very conspicuous with the Dunsink Equatoreal, or it would not have been referred to as a "point resembling a star," but it was undoubtedly well enough seen to make a definite point for placing the wires.

O. Struve from a single night found 293°·0 : 164''·40 (1848·73), and by two measures of the difference in declination in 1841 and 1848, 63''·5 and 64''·1.

The difference of the declination of the two stars, computed from my measures of the position-angle and distance, is 62''·20. This is 0''·7 less than Brunnnow's value, and should be much too large for the ordinary errors of observation, particularly in measures of this kind where the telescope is stationary, and the bisection of the stars is so easily and certainly made. After

learning of this difference I determined to see whether the value derived from the angle and distance would be confirmed by observing the difference of declination with the same instrument used in the direct measures. By this method I obtained the following:—

1891·652	Dif. Decl. = 62''·42
·655	62·31
·666	62·25
·671	62·34
1891·66	62·33

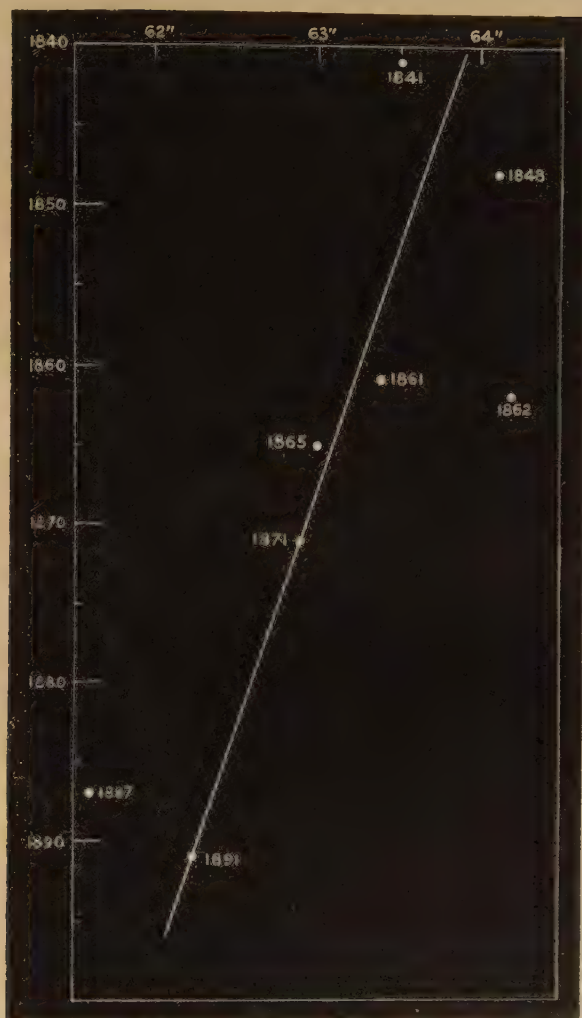
The difference between this result and that derived from the first series of measures is only 0''·13, a quantity which is insensible in direct measures of that distance, and within the limits of error in careful observations.

The various results found for the difference in the declination of these two stars, arranged in chronological order, are as follows:—

1841	Dif. Decl. 63''·5	0 Σ.
1848	64·1	0 Σ.
1861	63·4	Schönfeld.
1862	64·2	Argelander.
1865	63·0	Schultz.
1871	62·90	Brunnow.
1887	61·6	Engelhardt.
1891	62·26	β.

All of these measures appear to have been made with the micrometer with the exception of Argelander's, which were with the meridian circle (*Bonn Observations*, VI.).

These observations are laid off to scale on the accompanying diagram. It is apparent that there is a slow change in the declination of one of these stars, and that the difference is steadily decreasing. An examination of these positions, and omitting for this purpose those of 1862 and 1887, shows that the annual change in declination amounts to 0''·033. It is probably impossible to determine at this time to which star, if only one, this motion belongs.



Dreyer 6543.

Observed differences of Declination.

There are drawings of this nebula by Vogel (*Bothkamp Observations*, IV.), and by Holden and Schaeberle (*Mon. Not.* xlviii. 390).

No. 6563.

R.A. $18^h 2^m 48^s$ }
 Decl. $-33^\circ 53'$ }

This nebula is fairly planetary in appearance, and there seem to be some faint stars in it, but the central star is wanting. No drawings cited in Dreyer.

No. 6572.

R.A. $18^h 5^m 18^s$ }
 Decl. $+6^\circ 50'$ }

1891.575	77.0	33.02	10.5 . . .	14.5
.578	75.5	32.82	11.0 . . .	15.5
.597	76.6	33.08	11.0 . . .	15
1891.58	76.4	32.97	10.8 . . .	15

This is one of the brightest of the planetary nebulae. It is sometimes spoken of as Σ 6, which is an unfortunate as well as an improper method of referring to the list of nebulae observed by Struve, since the symbol Σ preceding a numeral has been universally used to designate the double stars comprised in the great catalogue of double stars, *Mensurae Micrometricae*.

There are drawings of this nebula by Secchi (*Mem. Coll. Rom.* 1852-5), and by Vogel (*Pub. Potsdam. Obs.* IV.). I have not seen these illustrations.

No. 6720.

R.A. $18^h 48^m 23^s$ }
 Decl. $+32^\circ 51'$ }

1891.326	88.2	61.64	15.5 . . .	12
.416	87.8	61.44	15.5 . . .	13.5
.419	86.5	61.56	15.5 . . .	12
.518	88.4	62.28	15 . . .	13
.559	88.0	61.56	15.5 . . .	11.5
1891.45	87.8	61.69	15.4 . . .	12.4

This is the well-known annular nebula in *Lyra*. All the measures were made under very favourable conditions, and the central star well seen. When the seeing was the best, and perfect for all practical purposes, the ring and the darker interior were carefully examined with various powers, but without detecting any other stellar point. In various places there are minute areas of slightly brighter nebulosity, but none of them appear to be stars. There are many drawings of this nebula. The

comparison star in the foregoing measures is the familiar one near the following edge of the nebula.

No. 6781.

R.A. $19^{\text{h}} 11^{\text{m}} 38^{\text{s}}$
Decl. $+6^{\circ} 17'$

1891.562	$72^{\circ} 1'$	$49'' 22$	15 . . . 12
.575	$74^{\circ} 5'$	$49'' 50$	15 . . . 13
1891.57	$73^{\circ} 3'$	$49'' 36$	15 . . . 12.5

The primary star is not central, but is north of the middle. Drawings have been made by Lamont and Lassell.

No. 6818.

R.A. $19^{\text{h}} 36^{\text{m}} 4^{\text{s}}$
Decl. $-14^{\circ} 29'$

This seems to present a true planetary appearance, but there is no central star. There appear to be two or three slight condensations of nebulous matter, which at first glance might be taken for faint stars, but I do not think they are real stellar points. There are drawings by Rosse, Lamont, D'Arrest, and Secchi.

No. 6826.

R.A. $19^{\text{h}} 41^{\text{m}} 2^{\text{s}}$
Decl. $+50^{\circ} 11' 2''$

1891.747	$194^{\circ} 1'$	$96'' 15$	9 . . . 10
.750	$194^{\circ} 4'$	$96'' 17$	8.7 . . . 9
1891.75	$194^{\circ} 2'$	$96'' 16$	8.8 . . . 9.5

This beautiful object is almost an exact duplicate of the planetary nebula in *Draco*. It is slightly elliptical, with the longer axis in the direction of 295° . A setting of the wires gave for the longer diameter $26'' 6$, and for the shorter $24'' 3$. There are a number of stars nearer than the one measured. The nearest, about $14 m$, is $27'' 0$ from the central star, in the direction of $283^{\circ} 1'$. Drawings have been made by Herschel and Secchi.

Engelhardt (*Observations Astron. II.*) by three measures made the difference of declination between the two stars, $93'' 5$ (1887.79). Computed from my angle and distance it is $93'' 2$.

No. 6891.

$$\left. \begin{array}{l} \text{R.A. } 20^{\text{h}} 8^{\text{m}} 32^{\text{s}} \\ \text{Decl. } + 12^{\circ} 19' \end{array} \right\}$$

Central star and *p* star *a*.

1890.785	242°3	42°67	11 . . . 12
.840	242°5	43°20	12 . . . 13
1890.81	242°4	42°93	11.5 . . . 12.5

Central star and *p* star *b*.

1890.802	289°0	57°15	12.5 . . . 11.5
.840	289°4	57°40	12 . . . 10.5
1890.82	289°2	57°27	12.2 . . . 11.0

In making the second measure a different comparison star was used, and therefore both were subsequently measured. This nebula was discovered by Copeland.

No. 6894.

$$\left. \begin{array}{l} \text{R.A. } 20^{\text{h}} 10^{\text{m}} 45^{\text{s}} \\ \text{Decl. } + 30^{\circ} 8' \end{array} \right\}$$

1891.594	186°7	119°65	15 . . . 11.5
.610	185°3	119°92	15 . . . 10.8
1891.60	186°0	119°78	15 . . . 11.1

Considerably darker in the middle, and apparently belongs to the annular class. The faint star within is not central, but is near the preceding side. There are many stars nearer the nebula than the 11 *m* comparison star. This nebula has been figured by Rosse (*Phil. Trans.* 1833). (*Trans. R. Dublin Soc.* II.)

No. 6905.

$$\left. \begin{array}{l} \text{R.A. } 20^{\text{h}} 16^{\text{m}} 9^{\text{s}} \\ \text{Decl. } + 19^{\circ} 40' \end{array} \right\}$$

1891.594	358°0	46°76	14 . . . 10
.610	357°2	46°61	14 . . . 10
1891.60	357°6	46°68	14 . . . 10

A measure of the diameter of this nebula in the direction of the 10 *m* star gave 39''·1. There are many drawings by the principal observers. Searle gives difference of declination between nebula and star (central star not mentioned) as 46''·33 (1867·65). (*Annals Harvard Coll. Obs.* XIII.)

No. 7009.

R.A. $20^{\text{h}} 56^{\text{m}} 33^{\text{s}}$
 Decl. $-11^{\circ} 55'$

1890.709	343 [°] 3	96 ^{''} 45	12.5 . . . 13
.725	343.7	96.55	11.5 . . . 12
.777	343.4	96.13	12 . . . 13
1890.74	343.5	96.38	12 . . . 12.7

There are many drawings of this object, sometimes called the "*Saturn* nebula," references to which will be found in Dreyer.

The following single measures are from the Rosse observations:—

1873.655	343 [°] 3	99 ^{''} 0
1874.695	343.3	101.2

No. 7026.

R.A. $21^{\text{h}} 1^{\text{m}} 33^{\text{s}}$
 Decl. $+47^{\circ} 17'$

1891.562	271 [°] 7	6 ^{''} 21
.575	272.6	6.40
.578	274.5	6.74
1891.57	272.9	6.45

This nebula was discovered by me in 1873 with the 6-inch refractor, with which it was also seen double or elongated. One of the nuclei is brighter than the other. The measures given above are of the angle and distance between these nuclei. They are not stars, but small enough for fairly accurate bisection. This object does not properly belong to the planetary class of nebulae. Some rough measures were made a few years ago which differ much from the results given here, but it is not probable that any change has occurred in the nebula.

No. 7027.

R.A. $21^{\text{h}} 1^{\text{m}} 48^{\text{s}}$
 Decl. $+41^{\circ} 40'$

1891.575	131 [°] 0
.578	135.1

Discovered by Webb. It has two nuclei, the following one of which is fairly well defined, but the brighter is too large and

diffused for reliable measures of distance. There is nothing planetary about the appearance of this nebula. The nearest star is 15 *m*, and is about 14'' from the bright condensation, in the direction of 96°.

No. 7208.

R.A. 21^h 59^m 25^s }
Decl. -29° 44' }

This is a faint circular nebula, but not specially planetary in appearance. Herschel's description is, "almost planetary."

No. 7354.

R.A. 22^h 35^m 8^s }
Decl. +60° 33' }

There seems to be a faint condensation near the margin of the nebula on the preceding side, but there is no central star; otherwise it presents the true planetary appearance. Dreyer has no reference to any drawings.

No. 7662.

R.A. 23^h 19^m 11^s }
Decl. +41° 46' }

1890·782	62°·4	51'·82	15 . . . 13
·785	63·4	51·87	15 . . . 13
1890·78	62·9	51·84	15 . . . 13

A number of drawings have been made of this nebula, references to which will be found in Dreyer. Searle (*Annals Harvard Coll. Obs.* XIII.) measured the outer star from the centre of the nebula (the central star not seen), and from two observations gives 62°·7 : 52''·14 (1866·80). O. Struve from four nights found 61°·3 : 51''·85 (1847·86). He states that the central star, which has been noted with the Rosse reflector, was not seen. (*Mélanges Math. et Ast.* III.)

Lick Observatory :
1891 October 14.

Corrections and Additions to the Observations of Sirius.

By S. W. Burnham, M.A.

In my paper on *Sirius* (*Monthly Notices*, April 1891), in the references to the various authorities on page 384 the name Eastman (*A.N.* 1526, 2678) should be changed to Engelmann, and Eastman should be added in another line with a reference to *Monthly Notices*, xxxviii. 360, and *A.N.* 1680. In the former are found his measures of 1878, given in the list of observations of that year on page 382 of my paper. The angle and distance of the companion are derived from observations with the Meridian Circle on three nights. The measures by this observer for 1867 are taken from the *Washington Observations* of that year, and not from *A.N.* 1680, where a slightly different value is given.

In the *Memoirs of the Royal Astronomical Society*, xxxvi. 38, observations of Lassell and Marth, there are some measures of the angle of the companion which are not included in the list I have given. It is not clear by whom the measures were really made. The mean result of three nights for the position-angle is $76^{\circ}8$ (1865-10).

I am indebted to M. Bigourdan, of the Observatory of Paris, for having called my attention to the omission of the following measures :—

1872.21	66.6	10.69	Börgen	3 ⁿ
1873.23	70.0	9.80	Börgen	1 ⁿ
1873.23	66.3	10.42	Bruhns	1 ⁿ
1880.18	46.7	9.92	Bigourdan	6-4 ⁿ
1881.14	44.3	10.62	Bigourdan	5-3 ⁿ
1882.13	42.4	9.76	Bigourdan	4-3 ⁿ
1883.19	39.9	9.10	Bigourdan	2-1 ⁿ
1884.17	35.3	8.79	Bigourdan	3-1 ⁿ

The first three are found in *Pub. Universitäts-Sternwarte zu Leipzig*, Heft, 1882. The observations of Bigourdan are printed in the *Annales de l'Observatoire de Paris* (Observations of 1883). I have never seen these volumes, and until this time was not aware of any such measures having been made. These are valuable observations, and should be added to the list I have given.

Mount Hamilton :
Oct. 19.

A Note on some Photometric Experiments connected with the Application of the Law of limiting Apertures to small Object-glasses. By Edmund J. Spitta.

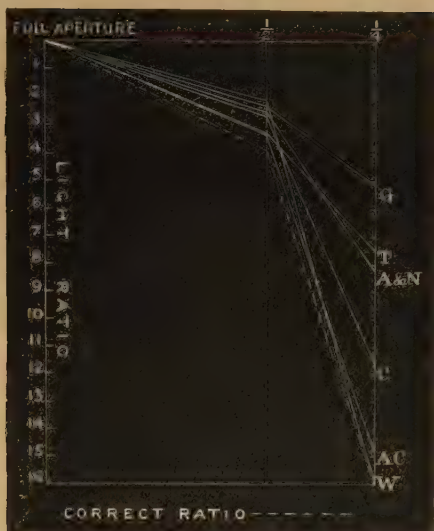
Whilst carrying out some experiments connected with the paper read before the Society in November last, certain doubtful and equivocal results immediately followed the application of a diaphragm to the telescope in use, and these were of so pronounced a character that the use of such means for reducing the intensity of the luminant had to be abandoned. It was known a doubt had always existed as to whether the intensity of a point of light viewed at the focus of a refracting telescope would, when photometrically tested, be found to vary as the square of the linear aperture of the object-glass; in other words, whether it was scientifically accurate or strictly philosophical, seeing its compound nature and its different mode of manufacture, to apply to an object-glass what is generally known as the law of limiting apertures.

Having, therefore, tested photometrically the different zones of this object-glass, and proved that the law (anyhow, with the telescope in question) was *not* applicable, it was thought it would be of interest, seeing the subject had not received any extended investigation, to photometrically test objectives of different makers' manufacture, both English and foreign. Although at present I have only been able to examine telescopes of small aperture, the results furnish me with figures so different, although all in the same direction, that it has been suggested it would be of interest to publish this preliminary note.

In the accompanying table the first column gives the distinguishing name of the object-glass examined; the second and third its aperture and focal length; whereas the fourth and last set forth the actual ratios photometrically obtained, when the aperture was lineally reduced to one-half and one-quarter respectively.

Table of Ratios photometrically obtained.

		inches.	inches.		
I.	Alvan Clark	6.5	93	 I : $\frac{1}{3.35}$	 I : $\frac{1}{14.84}$
II.	Tulley	3.1875	46.5	 I : $\frac{1}{3.3}$	 I : $\frac{1}{7.5}$
III.	Clerkenwell	2.625	42	 I : $\frac{1}{2.63}$	 I : $\frac{1}{11.70}$
IV.	Watson	2.8125	41	 I : $\frac{1}{2.11}$	 I : $\frac{1}{15.91}$
V.	Grubb	2.875	40.8	 I : $\frac{1}{2.31}$	 I : $\frac{1}{5.07}$
VI.	A. and N.	2.375	24.75	 I : $\frac{1}{2.47}$	 I : $\frac{1}{8.23}$



On examination both the table and the diagram show that in all cases, except perhaps that of the object-glass by Alvan Clark, the rays passing through the outer zones do not contribute to the intensity of the focal image as much as theoretically they should. It would seem, too, that focal length is not a factor of importance, as the resulting ratios, although all in the same direction appear to be different in each case, even when the dimensions are nearly similar. But I submit, however, that a solution of the difficulty very possibly lies in the aplanatisation of the respective glasses. With any of the modifications of the zonal treatment it is not difficult to understand that in some instances perfection of definition at the focus has not arisen from a combination of those rays of the spectrum selected by the optician to be united from *all parts* of the object-glass, but has been effected, unconsciously it may be in some cases, by pushing the focus of the rays from the outer zones aside, so as to be finally lost or cut off by suitable diaphragms. This is much the same as when the artist in achromatising neglects the rays from the extreme ends of the spectrum, or permits their focus to be at some place other than that occupied by the visual focus. If the object-glasses I examined were made somewhat in this way, it is easy to perceive how it came about that the application of a large diaphragm, *i.e.* one of large aperture placed between them and the source of light, did not appropriately reduce the brilliancy of the image at the focus. In other words, it would be evident the reason the large diaphragms had not affected the resulting ratios in a manner they should was due to the fact that they were placed over

portions of each object-glass, which only contributed in a slight degree to the intensity of the image at the focus.

This suggestion, which I venture to submit for the consideration of those better versed in practical optics, was forced upon me by the peculiar phenomena displayed by one of the telescopes I purposely examined photometrically with diverging light (which, of course, very much exaggerated the true state of things). I was surprised to find, when all the internal diaphragms were removed, that the rays from the outermost zone had a focus very sensibly different in length to those from the neighbouring and central ones. Yet the object-glass, when examined as set in its tube, had given much satisfaction in defining powers, going in and out of focus with considerable rapidity. Of course, the use of truly parallel rays, such as are received from a star, would, and indeed were, on trial, actually found to materially alter this state of things, but it was the fact itself that seemed of some importance, as it appeared to me to point in what direction it might be possible to find a solution capable of explaining the different figures that resulted when the law of limiting apertures was applied to the several object-glasses I had examined. It was thought, too, that this explanation would offer a suggestion how it came about that Dr. V. L. Charlier, in *Publications of the Astronomical Society of the Pacific*, No. 17, had actually seemed to prove that the use of diaphragms did not in his telescope control the photographic intensity of a point of light according to theoretical considerations.

Again, too, if such reasoning be true, it is not difficult to see why half the linear aperture of a large telescope has so often been noticed to reveal fainter stars than the full aperture of another of the same linear dimensions.

Another experiment was tried which is of sufficient negative interest to merit being recorded. It was suggested that the peculiar figures of the table perhaps resulted for the most part from differences in the angles of incidence at which the cylindrical beam received from a star impinged upon different zones of the curved anterior surface of each objective respectively. Accordingly, the Clerkenwell object-glass was reversed in its cell so that the posterior surface of its flint glass, which was sensibly flat, should receive the rays from the source of light; but it was found that the ratios did not differ more than by a reasonable observational error from those given in the table, which were obtained with the objective in its normal position.

It is, perhaps, worth mentioning, that on studying the literature of the subject, I find I am not alone in obtaining the peculiar figures of the table, for Dr. Müller, of Potsdam,* working with a Zöllner photometer, reduced his aperture in such

* *Publicationen des Astrophysikalischen Observatoriums zu Potsdam—Photometrische Untersuchungen.*

ratios that the computed values of the logarithms of brilliancy of a star were:—

1·0742
0·7959
0·4437

but the observed ratios were:—

0·3695
0·3439
0·2687

He remarks, therefore, that the rays coming through the outer parts of his object-glass had very little effect on the brilliancy of the image; and it was only when the diameter had been diminished, say about one half, that the observed and computed ratios had a tendency to agree. But, he adds, that with a larger telescope of 135 mm. aperture—that is, about five and a quarter inches—the difference between the observed and computed ratios became almost nil. This corresponds very approximately with my own experience.

Wolff,* too, after conducting several experiments with an object-glass of 37·4 mm. diameter, comes to much the same conclusion, although, as a matter of fact, I am not able to find that he carried his investigation any further with telescopes of larger proportions.

As it has been pointed out to me, the value of the figures in the table would be increased by giving some of the actual wedge-readings; I select the two sets from which the mean values of the performance of the Grubb objective have been obtained, because they were taken on two different nights. When these are reduced it has been found that the resulting ratios do not differ *inter se* by a quantity much greater than ·1 magnitude.

Full ap.	$\frac{1}{2}$ ap.	$\frac{1}{3}$ ap.	Full ap.	$\frac{1}{2}$ ap.	$\frac{1}{3}$ ap.
3·19	1·40	0·33	4·30	2·29	0·65
3·23	1·75	0·32	3·75	2·32	0·82
3·23	1·60	0·29	3·63	2·47	0·80
3·20	1·48	0·33	3·85	2·47	0·75
3·23	1·53	0·5	3·73	2·30	0·64
		0·39		2·40	
M. 3·21	1·55	0·36	3·85	2·37	0·73

It will be noticed that on two occasions six observations were accidentally taken instead of five.

1891 November.

* *Photometrische Beobachtungen an Fixsternen*, 1878, pages 20–22.

On New Forms of Levels. By H. H. Turner, M.A., B.Sc.

The striding or hanging level in its usual form has so often given erroneous results that it is perhaps unnecessary to quote instances in detail. The errors chiefly arise from want of uniformity in the scale; and it is no doubt a serious difficulty to obtain a tube of glass of sufficiently slight and sufficiently uniform curvature to make the scale even approximately the same in different portions of its length. Moreover, the usual method of dealing with an erroneous scale—careful determination of the division errors by calibration—is not here completely applicable; for the length of the bubble changes with temperature, and the division errors for one temperature are not the same as for another. Experiments made in 1889 on some level bubbles used in the determination of the Paris-Greenwich longitude showed that this effect of changes of temperature was perhaps not so great as might be expected, and that a table might be formed at a mean temperature for correcting the mean of the readings of the ends of the bubble, which would apply without serious errors at all moderate temperatures. But this process cannot be called satisfactory when great accuracy is desired.

It occurred to me recently that we could be independent of this unsatisfactory scale if the small screw for adjustment of zero of the bubble were made a fine micrometer screw. This screw would then be turned until the bubble took up a definite position on the scale, and the micrometer head read; on reversing the bubble the screw would again be turned until the same position was reached, and the head again read. The difference of readings of the screw is then twice the level error, and the scale is no longer used except as a series of fiducial marks, any one of which may be selected according to convenience. Messrs. Troughton & Simms readily undertook to make an experimental level-bubble on this plan, and the only practical difficulty they encountered was in providing a fine enough screw. They ultimately decided to obtain the requisite sensitiveness by making the screw act on a system of levers instead of one lever only. A striding-level with micrometer screw was received from them on 1891 July 7, and found to work satisfactorily. Three others were therefore made for use with the portable transits in the proposed Montreal-Greenwich longitude operations, which it was hoped to commence this year, but which were finally deferred until 1892. The use of these levels in the meantime with one or other of the portable transits* has suggested the following remarks:—

* The Transit Circle object-glass was removed by Messrs. Troughton & Simms for repolishing on 1891 August 10, and the transits were in constant use for time determination at the Royal Observatory from that date until October 5.

I. The addition of the screw does not, of course, diminish but increases the time required for an observation of level and the probable error of a single observation, for there are now two things to observe instead of one, and two sources of error. It is the systematic and not the accidental errors that are diminished. In practice, I think, it will be found best to make each observation of level consist of four distinct operations, somewhat as follows :—

Reading of Screw.	Direction of Motion.	Readings of Bubble.	
		E. <i>d</i>	W. <i>d</i>
9'500	Incr.	15'2	69'6
9'500	Decr.	15'6	69'9
10'000	Incr.	69'0	14'7
10'130	Decr.	71'2	17'0

The first pair of readings is taken without disturbing the instrument, except to turn the screw head in opposite directions to the reading 9'500. The slight difference of readings of the bubble will be referred to presently (IV.). The level is then reversed and another pair taken. To avoid holding the screw too long with the fingers, and thus possibly warming one end of the level, it is set quickly to a reading estimated to be approximately that which will bring the bubble to its old position; and the error of this estimation, which becomes obvious on taking the readings of the bubble, is corrected in the second setting of the screw by arranging that the mean of the second pair of bubble readings shall be nearly the same as the mean of the first pair. If the relation between the value of a revolution of the screw and that of one division of the scale is even approximately known, this coincidence of the mean readings can be readily secured with considerable accuracy. The present example was chosen as a rather unfavourable instance, the difference of the means ($42^{\text{d}}.98$ and $42^{\text{d}}.58$) being $0^{\text{d}}.4$, and for this a correction must be applied, depending on the value of the bubble-scale; but it is obvious that no sensible error in level will be introduced by a moderately erroneous scale value for such a small quantity.

II. The additional labour during the operations is to some extent compensated by a saving in preliminary determination of constants. The evaluation of the screw is much less laborious than the calibration of the scale, for the want of uniformity in different parts is much smaller, and, in fact, should be insensible if the screw is properly made by a good maker; whereas no one has yet apparently succeeded in making uniform bubble-scales. Moreover, the evaluation of some screw, viz. that of the level-prover, is also necessary for the ordinary form of level-bubble; and consequently the requisite labour is to some extent common to both cases. The new form of level is, in fact, simply a combination of level and prover in one instrument.

III. It may be remarked that there is a definite advantage gained in the possibility of selecting the part of the scale to be used. Not only can certain accidental errors be eliminated by using different parts of the scale at different times during the observations, but the more defective parts of the scale may be avoided. Such are either:—

(a) Parts where the value of a division changes most rapidly. If the scale of an ordinary level be calibrated, and the value of one division at different parts of the scale be plotted on paper in the ordinary way, the resulting curve generally has one or more points of inflexion. At these points the rate of change in the value of one division is a maximum, and the accidental error of an observation is therefore large. A rough calibration of the scale for the detection of such points is therefore advisable even when the micrometer screw is added, so that readings of the bubble at such points may be avoided; and on the other hand, of course, the best points to select for readings should be chosen, which are those where the curve indicates a uniform scale.

(b) Parts where there is something in the nature of a frictional obstruction in the glass. Without further comment I may perhaps refer to a note by Mr. G. C. Comstock in the *Sidereal Messenger* for 1891 June, p. 299. Referring to a remark of Prof. Safford's, that "In some cases impurities in the ether dissolve particles of the glass, loosen other particles, and make the bubble sluggish by adhesion," Mr. Comstock continues: "It is interesting to note that this peculiarity of levels has been made the subject of special study by one of the scientific bureaux of the German Government," and gives the following account of the results attained:—

"In the course of time secretions are formed upon the inner surface of the glass and render the level unfit for use. It has been ascertained by experiment that these are due to the action of the water, traces of which are usually found in the ether with which the levels are filled. Since it is exceedingly difficult to fill a level with ether which is entirely free from water, a kind of glass which is but little affected by the action of water should be chosen in the construction of the level. A method for testing this quality of the glass by means of a colour reaction has been devised, and may easily be applied even by an unskilled person. Let a glass tube be filled with a solution of water and ether containing also a little eosin. After the solution has stood for some time in the tube the glass will assume a ruddy tint, and the greater the action of the water upon the glass the more pronounced will this tint become. By the decomposition of the glass a certain quantity of alkali is liberated and is transformed by the eosin into a coloured salt.

"The conclusion of the whole matter reached by the author of the report is, that a level tube before it is filled should always be subjected to a special treatment, consisting in removing from

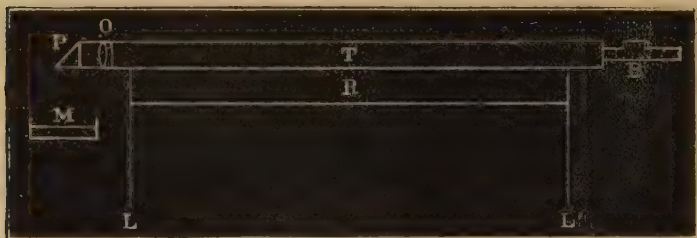
the ground-glass surfaces their alkaline components by means of an acid."

IV. It may be questioned whether a certain amount of sluggishness is not discernible in all bubbles. In a sensitive level the bubble approaches the position of equilibrium gradually, and may take several minutes of time to reach it. Readings taken before the end of this time will be in excess or defect according as the bubble is moving in the negative or positive direction. The screw provides a means of giving a gentle motion in opposite directions, and thus sensibly eliminating any errors which may be introduced by the necessity for reading without wasting too much time. An example was given in remark I., and is fairly representative, the difference of $0^d.35$ between the readings of the bubble when brought to the same reading ($9^d.500$) of the screw, but in opposite directions, being about the mean of such observed differences for the four levels used at Greenwich. Of course with the ordinary form of level such a motion may be given by a gentle tilt with the hand, though this is more liable to be jerky; and it is to be feared that the tendency is rather to set the level down indifferently and trust to the errors balancing in the long run, though it is quite conceivable that a habit might be acquired of setting down one end always first, in which case a systematic error would be introduced.

V. Level bubbles are sometimes permanently attached to instruments (as in the altazimuth used at the Royal Observatory, Greenwich), and are only reversed in the reversal of the instrument. In such cases, changes of temperature are apt to alter the zero of the bubbles so that they run off the scale for some positions of the instrument, unless the adjusting screws are altered to correspond. The addition of a micrometer screw to such levels would not indeed remove the necessity for altering the adjusting screw, but would rather make it a necessary part of every observation, so that the alteration would not be unexpectedly found necessary at an inconvenient time, as is sometimes the case at present when bad weather has interrupted the observations for some time.

The announcement of the above paper suggested a new form of level to Dr. A. A. Common, which he has asked me to describe briefly in an additional note. He proposes to combine some of the advantages of the nadir-observation and the striding-level determination and avoid some of their disadvantages, in a new instrument which can be readily placed on the pivots in various positions of the latter, reversed end for end, or removed, just as the striding-level, and the fundamental principle of which shall be reflexion from mercury as in the nadir-observation, instead of the motion of an air-bubble. The cylindrical tube joining the uprights of this instrument is a telescope tube, a flat bar being added above or below the tube to ensure rigidity. To the object-glass is firmly attached a reflecting prism, and the

eyepiece is a Bohnenberger, with wire frame. The light from the wires passes through the object-glass and is reflected vertically downwards by the prism to a trough of mercury placed underneath the projecting face of the prism, is returned to this face of the prism and back through the telescope, forming an image of the wires in the same plane as themselves. A micrometer screw applied either to the whole telescope and prism, or to the wires alone, will give a reading for coincidence, the difference of which, from a similar reading for coincidence in the reversed position of the instrument, will be twice the level error. No instrument of this kind has yet been constructed, and it may be found necessary to modify the details; but the principle is in some ways new, and it was thought advisable to include this brief sketch of the idea in the present paper. A diagrammatic section of the proposed instrument would be somewhat as below.



B = Bohnenberger eyepiece. The illumination of the wires may be effected by the axis-lamp of the transit by an additional prism to throw this light upwards towards the reflector in B.

O = object-glass of telescope T.

P = reflecting prism.

M = Mercury trough.

L, L' = legs to stand on pivots, as in the striding-level.

R = flat bar to strengthen the connections.

On the Conjunction of Venus and Jupiter, 1892 February 5-6.
By A. Marth.

The close conjunction of *Venus* and *Jupiter*, predicted in the Almanacs as occurring on February 5 at 22^h Greenwich mean time, offers to observers in Australia, in Japan, and in adjacent terrestrial regions the rare chance of making the simple observations required for answering the question, What are the limits of angular distance within which such bright bodies can or cannot be separated by the naked eye? The geocentric distance between the centres of the two planets will be

$$\begin{array}{ccccccc} & & \text{h} & \text{m} & & \text{h} & \text{m} \\ \text{within } 3' & \text{from } 21 & 4 & \text{to } 23 & 24 & \text{G.M.T.} \\ \text{,, } 2 & \text{,, } 21 & 29 & \text{,, } 22 & 59 & \text{,,} \end{array}$$

As the observations require no artificial means except watches or clocks for knowing the correct time, and consist merely in watching the planets after sunset and noting the times when they cease to appear separated and when they begin to appear so again, it is to be hoped that the interesting phenomenon will be duly observed by very many pairs of eyes, and that the best use will be made of the rare opportunity.

On the present occasion the planets will be 33°·6 east of the Sun. On the last occasion, 1826 August 1, when a close conjunction of *Venus* and *Jupiter* took place in the evening, the angular distance from the Sun was 36°·2, and Australia was again favoured, but I do not know whether any observations were got at Paramatta. Since then a close morning conjunction occurred 1859 July 20, 16^h Greenwich mean time, but the planets were only 18°·5 west of the Sun, and no results of value were obtained.

The position-angle p and the angular distance s of the centre of the disc of *Venus* referred to that of *Jupiter* may be obtained by means of the formulæ

$$\begin{aligned} s \sin (p-P) &= x = x_0 - [0\cdot3498] \rho'' + [0\cdot6771] \rho' \sin (G + \lambda) \\ s \cos (p-P) &= y = y_0 - [0\cdot6743] \rho'' - [0\cdot3577] \rho' \sin (H + \lambda), \end{aligned}$$

in which x_0 y_0 denote the geocentric rectangular coordinates of *Venus* referred to the axes of the disc of *Jupiter*, and x y the corresponding topocentric coordinates for a place in longitude λ east of Greenwich, the distance of which from the axis of the Earth is ρ' , and from the plane of the equator ρ'' (reckoned negative for places on the south side). The logarithmic coefficients of ρ'' and ρ' are those for 22^h Greenwich and vary slightly, the values for 18^h being '0004 smaller, and for 2^h '0004 greater. The quantities x_0 y_0 , G , H have the following values:—

	G.M.T.	x_0	y_0	G	H
1892.	h m				
Feb. 5	18 0	-635 ^{''} 19	-41 ^{''} 34	56 [°] 23	44 [°] 12
	20	585 ^{''} 21	33	61 [°] 24	49 [°] 13
	40	535 ^{''} 23	31	66 [°] 25	54 [°] 15
	19 0	-485 ^{''} 26	-41 ^{''} 29	71 [°] 26	59 [°] 16
	20	435 ^{''} 28	28	76 [°] 27	64 [°] 17
	40	385 ^{''} 31	26	81 [°] 28	69 [°] 19
	20 0	-335 ^{''} 34	-41 ^{''} 24	86 29	74 [°] 20
	20	285 ^{''} 37	22	91 [°] 30	79 [°] 21
	40	235 ^{''} 40	20	96 [°] 31	84 [°] 23
	21 0	-185 ^{''} 43	-41 ^{''} 17	101 [°] 32	89 [°] 24
	20	135 ^{''} 46	15	106 [°] 33	94 [°] 25
	40	85 ^{''} 49	13	111 [°] 34	99 [°] 27
	22 0	-35 ^{''} 53	-41 ^{''} 10	116 [°] 35	104 [°] 28
	20	+ 14 ^{''} 44	08	121 [°] 36	109 [°] 29
	40	64 ^{''} 40	05	126 [°] 37	114 [°] 31
	23 0	+ 114 ^{''} 36	-41 ^{''} 02	131 [°] 38	119 [°] 32
	20	164 ^{''} 32	41 ^{''} 00	136 [°] 39	124 [°] 33
	40	214 ^{''} 28	40 ^{''} 97	141 [°] 40	129 [°] 35
Feb. 6	0 0	+ 264 ^{''} 24	-40 ^{''} 94	146 [°] 41	134 [°] 36
	20	314 ^{''} 20	91	151 [°] 42	139 [°] 37
	40	364 ^{''} 15	88	156 [°] 43	144 [°] 39
	1 0	+ 414 ^{''} 10	-40 ^{''} 85	161 [°] 44	149 [°] 40
	20	464 ^{''} 05	82	166 [°] 45	154 [°] 41
	40	514 ^{''} 00	78	171 [°] 46	159 [°] 43
	2 0	+ 563 ^{''} 94	-40 ^{''} 74	176 [°] 47	164 [°] 44

The values of the position-angle P of *Jupiter's* axis and of the apparent diameters of the disc may be taken from the ephemeris in vol. li. page 367. The assumed value of the diameter of *Venus* at distance 1 is $17''.552$, q denotes the amount of the greatest defect of illumination, and Q its position-angle reckoned from the circle of declination, or $Q-P$ the position-angle reckoned from the direction of the axis of *Jupiter*.

		$\mathcal{J}$'s Diam.				$\mathcal{V}$'s Diam.		
G.M.T.	P	Equat.	q	Polar.	q	Q	Q-P	
Feb. 5	h 18	334 [°] 708	34 ^{''} 04	0 ^{''} 11	31 ^{''} 87	13 ^{''} 52	2 ^{''} 31	0 0
	6 2	705	34 ^{''} 01	0 ^{''} 10	31 ^{''} 86	13 ^{''} 54	2 ^{''} 33	68.5 93.8

The rectangular coordinates of the satellites referred to the axes of *Jupiter's* disc, and deduced from the data published in vol. li.,

are for the times when *Venus* is passing in their neighbourhood, the following:—

Sat. IV.			Sat. II.			
G.M.T.	x_1	y_1	G.M.T.	x_2	Diff.	y_2
h m			h m			
19 0	-43 ¹ 05	+3 ⁷ 96	21 0	-127 ¹ 36	+1 ¹ 16	+1 ¹ 77
20	430 ³ 38	4 ⁰ 01	10	126 ² 20	1 ² 29	1 ⁸ 3
40	429 ⁷ 0	4 ⁰ 06	20	124 ⁹ 1	1 ⁴ 43	1 ⁸ 9
20 0	-429 ⁰ 2	+4 ¹ 11	30	123 ⁴ 8	+1 ⁵ 56	1 ⁹ 5
			21 40	-121 ¹ 92		+2 ⁰ 1
Sat. I.			Sat. III.			
G.M.T.	x_1	y_1	G.M.T.	x_3		y_3
21 40	-64 ¹ 68	-2 ¹ 24	23 40	+256 ¹ 73		+0 ¹ 70
45	65 ⁶ 4	2 ² 22	50	77		0 ⁶ 6
50	66 ⁵ 8	2 ² 20	0 0	80		0 ⁶ 2
55	67 ⁵ 1	2 ¹ 17	10	81		0 ⁵ 7
22 0	-68 ⁴ 3	-2 ¹ 15	0 20	+256 ⁸ 1		+0 ⁵ 3

According to these data, the geocentric conjunctions of *Venus* with the satellites and with *Jupiter* will take place at the following Greenwich mean times:—

Sat. IV.	Sat. II.	Sat. I.	4	Sat. III.
h m	h m	h m	h m	h m
19 22 ⁰	21 24 ⁵	21 47 ⁷	22 14 ²	23 57 ⁰

the distances being

-45 ¹ 3	-43 ¹ 1	-38 ¹ 9	-41 ¹ 1	-41 ¹ 7
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As the sum of the semidiameters of the two planets at the time of nearest approach is 22¹7, the distance between the nearest limbs will be, geocentrically, only 18¹4, and their distance will be reduced by parallax for Adelaide to 14¹0, for Sydney and Windsor to 13¹9, and for Melbourne to 13¹8.

Whether the satellites can be successfully observed in day-time remains to be tested.

Col. Cooper's Observatory,
Markree, Colloonsy, Ireland.

Ephemerides of the Satellites of Saturn, 1891-92. By A. Marth.
(Continued.)

The adopted Zero-Meridian will pass the middle of the illuminated disc of Saturn at the following Greenwich mean times :—

1891.	h. m.	h. m.	1892.	h. m.	h. m.
Dec. 22	11 56.8	22 11.1	Jan. 26	11 31.5	21 45.9
23	8 45.5	18 39.8	27	8 0.2	18 14.5
24	15 8.5	25 22.8	28	4 28.8	14 43.6
25	11 37.2	21 51.5	29	11 11.7	21 26.0
26	8 5.8	18 20.2	30	7 40.3	17 54.7
27	14 48.9	25 3.2	31	4 9.0	14 23.3
28	11 17.5	21 31.9	Feb. 1	10 51.9	21 6.2
29	7 46.2	18 0.6	2	7 20.5	17 34.8
30	14 29.2	24 43.5	3	3 49.1	14 3.4
31	10 57.9	21 12.2	4	10 32.1	20 46.4
1892.			5	7 0.7	17 15.0
Jan. 1	7 26.6	17 40.9	6	3 29.3	13 43.6
2	14 9.5	24 23.9	7	10 12.2	20 26.5
3	10 38.2	20 52.5	8	6 40.8	16 55.1
4	7 6.9	17 21.2	9	3 9.4	13 23.7
5	13 49.9	24 4.2	10	9 52.3	20 6.7
6	10 18.5	20 32.9	11	6 21.0	16 35.3
7	6 47.2	17 1.5	12	2 49.6	13 3.9
8	13 30.2	23 44.5	13	9 32.5	19 46.8
9	9 58.8	20 13.1	14	6 1.1	16 15.4
10	6 27.5	16 41.8	15	2 29.7	12 44.0
11	13 10.4	23 24.8	16	9 12.6	19 26.9
12	9 39.1	19 53.4	17	5 41.4	15 55.5
13	6 7.7	16 22.0	18	2 9.8	12 24.1
14	12 50.7	23 5.0	19	8 52.8	19 7.1
15	9 19.3	19 33.6	20	5 21.4	15 35.7
16	5 48.0	16 2.3	21	12 4.3	22 18.6
17	12 30.9	22 45.2	22	8 32.9	18 47.2
18	8 59.6	19 13.9	23	5 1.5	15 15.8
19	5 28.2	15 42.5	24	11 44.4	21 58.7
20	12 11.1	22 45.5	25	8 13.0	18 27.3
21	8 39.8	18 54.1	26	4 41.6	14 55.9
22	8.4	15 22.7	26	11 24.6	21 38.9
23	1 51.4	22 5.7	28	7 53.2	18 7.5
24	8 20.0	18 34.3	29	4 21.8	14 36.1
25	4 48.6	15 2.9			

The planetary longitudes of several spots, deduced from the times of their crossing the middle line of the disc, as observed by Mr. A. Stanley Williams (v. No. 3051 of the *Astron. Nachrichten*), are in the adopted system of longitudes :

1891.	G.M.T. h m	Long. °		G.M.T. h m	Long. °		G.M.T. h m	Long. °
May 12	11 50	3°1	May 7	9 50	34°1	May 7	9 57	38°2
30	9 51	0°1	June 5	10 17	37°5	13	9 33	46°5
June 2	9 38	3°5	14	9 17	35°4	June 11	10 2	50°7
5	9 13	0°0	17	9 4	38°8	14	9 32	44°2
11	8 43	4°5	20	8 39	35°2	17	9 16	45°8
14	8 19	1°4				20	8 58	46°3
						26	8 24	48°4
	G.M.T. h m	Long. °		G.M.T. h m	Long. °			
May 13	10 26·5	77°9	May 11	9 27	155°6			
22	9 42	85°2	June 9	9 50	156°3			
28	8 57	81°1	12	9 36	159°2			
31	8 37	80°4	18	9 2	161°3			
June 11	11 0 est.	84°7						
20	10 5	85°6						
26	9 33	88°8						
29	9 11	86°9						
July 2	8 40	79°8						

The longitude and latitude of the centre of the disc at the times assigned to Mr. Williams's sketches are :—

		G.M.T. h m	Long. °	Lat. °
Fig. 1	May 7	9 50	34°1	-5°5
2	May 13	9 33	46°5	-5°5
3	June 5	9 32	11°1	-5°2

and at the time of fig. 1 made at the Lick Observatory,

April 27 16^h 32^m 112°·2 -5°·4

the fig. being published on p. 498 of the *Journal of the British Astronomical Association*.

In the list of approximate Greenwich mean times of conjunction of the satellites with the end points of the equatorial diameter of the ball and with those of the ring, the letters $\alpha \beta \gamma \delta$ denote the position of the satellites when they are in conjunction with the end points of the equator in the order "north following, south following, south preceding, and north preceding," and $\epsilon \zeta \eta \theta$ the corresponding positions as regards the end points of the ring. "Ecl. D." and "Ecl. R." denote the disappearance and reappearance of the satellite or the beginning and ending of an

eclipse, "Sh." the axis of its shadow-cone crossing or being near the central meridian of the planet's disc. It is to be understood that the times given are only intended for approximate guidance. At the conjunctions of *Titan* with the centre the coordinates of the satellite ought to be most carefully measured.

G.M.T.		G.M.T.		G.M.T.	
1891.	h	1891.	h	1891.	h
Dec. 22	13 ⁵ Titan ζ	Dec. 26	21 ² Rh. ϵ	Dec. 31	0 ⁰ Titan Ecl. R.
	15 ⁰ Titan Sh.		21 ⁷ Te. β		0 ⁵ Mi. ϵ
	16 ³ En. ζ		22 ⁶ Te. Sh.		0 ⁶ Rh. θ
	17 ⁴ Titan β	27	0 ² Mi. θ		1 ⁶ Rh. Ecl. D.
	18 ⁴ Mi. ζ		0 ⁶ Te. γ		2 ⁸ Titan sup. δ
	20 ³ Titan inf. δ		1 ⁰ Di. θ		with centre
	with centre		1 ³ En. η		11 ⁰ n.
	10 ⁶ s.		2 ² Di. Ecl. D.		11 ² Di. η
	22 ⁴ Di. ζ		17 ⁴ Mi. η		11 ⁸ Mi. η
	22 ⁶ En. η		17 ⁷ En. ϵ		13 ⁰ Te. θ
	23 ² Titan γ		18 ³ Te. ζ		14 ⁰ En. θ
23	0 ³ Mi. η		19 ⁷ Te. Ecl. D.		14 ³ Te. Ecl. D.
	0 ⁶ Di. β		22 ⁸ Mi. θ		17 ² Mi. θ
	1 ¹ Te. ζ		23 ² Te. α		17 ⁹ Te. α
	1 ⁵ Di. Sh.	28	1 ² Te. ϵ		19 ⁹ Te. ϵ
	15 ¹ En. ϵ		12 ⁰ Di. β		20 ⁴ En. ϵ
	17 ⁰ Mi. ζ		12 ⁸ Di. Sh.		23 ¹ Mi. ϵ
	22 ⁹ Mi. η		15 ³ Di. γ		
	23 ⁷ Te. θ		16 ⁰ Mi. η	1892	
24	1 ¹ Te. Ecl. D.		17 ⁰ Te. ζ	Jan. 1	11 ⁶ Te. ζ
	1 ² En. ζ		17 ⁵ Di. η		12 ³ Di. θ
	12 ⁴ Rh. γ		18 ⁴ Rh. ζ		12 ² En. η
	12 ⁸ Di. α		19 ⁰ Te. β		13 ⁶ Di. Ecl. D.
	15 ⁰ Rh. η		19 ⁹ Te. Sh.		13 ⁶ Te. β
	15 ⁰ Di. ϵ		20 ³ En. θ		14 ⁵ Te. Sh.
	15 ⁶ Mi. ζ		21 ⁰ Rh. β		15 ⁹ Mi. θ
	17 ⁶ En. θ		21 ⁴ Mi. ζ		16 ⁵ Te. γ
	21 ⁵ Mi. η		21 ⁵ Rh. Sh.		17 ⁸ Di. α
	22 ⁴ Te. ζ		21 ⁹ Te. γ		18 ⁵ Te. η
	23 ⁹ En. ϵ		23 ⁹ Te. η		20 ⁰ Di. ϵ
25	0 ⁴ Te. β	29	0 ⁸ Rh. γ		21 ⁸ Mi. ϵ
	1 ³ Te. Sh.		12 ⁷ En. ζ		22 ⁹ En. θ
	14 ² Mi. ζ		14 ⁶ Mi. η	2	11 ⁶ Te. Ecl. D.
	16 ¹ Di. ζ		15 ⁷ Te. θ		13 ³ Rh. γ
	16 ⁴ En. η		17 ⁰ Te. Ecl. D.		14 ⁵ Mi. θ
	18 ³ Di. β		18 ⁷ Di. θ		15 ² Te. α
	19 ² Di. Sh.		19 ⁰ En. η		15 ⁴ En. ζ
	20 ¹ Mi. η		19 ⁹ Di. Ecl. D.		15 ⁸ Rh. η
	21 ⁰ Te. θ		20 ⁰ Mi. θ		17 ² Te. ϵ
	21 ⁶ Di. γ		20 ⁶ Te. α		20 ⁴ Mi. ϵ
	22 ⁴ Te. Ecl. D.		22 ⁶ Te. ϵ		21 ² Di. ζ
	23 ⁸ Di. η	30	0 ¹ Di. α		21 ⁷ En. η
26	1 ⁵ Mi. θ		13 ² Mi. η		23 ⁴ Di. β
	1 ⁹ Te. α		14 ³ Te. ζ	3	0 ² Di. Sh.
	12 ² Rh. θ		16 ³ Te. β		13 ¹ Mi. θ
	12 ⁸ Mi. ζ		17 ² Te. Sh.		13 ⁸ Te. γ
	13 ² Rh. Ecl. D.		18 ⁴ Titan Ecl. D		14 ¹ En. ϵ
	18 ⁶ Rh. α		18 ⁶ Mi. θ		15 ⁸ Te. η
	18 ⁸ Mi. η		19 ² Te. γ		19 ⁰ Mi. ϵ
	18 ⁹ En. ζ		21 ² Te. η	4	12 ⁵ Te. α
	19 ⁷ Te. ζ		21 ⁶ En. ζ		13 ¹ Rh. θ
					13 ⁷ Di. ϵ

G.M.T.		G.M.T.		G.M.T.	
1892.	h	1892.	h	1892.	h
Jan. 4	14 ¹ Rh. Ecl. D.	Jan. 9	18 ¹ En. η	Jan. 14	20 ⁵ Mi. θ
	14 ⁵ Te. ϵ		18 ⁷ Di. Ecl. D.		21 ⁶ Te. γ
	16 ⁷ En. θ		22 ⁰ Mi. η		23 ³ En. ζ
	17 ⁶ Mi. ϵ		22 ⁹ Di. α		23 ⁶ Te. η
	19 ⁵ Rh. α		23 ⁵ Te. θ	15	10 ² Di. α
	22 ¹ Rh. ϵ		10 0 ⁹ Te. Ecl. D.		12 ⁴ Di. ϵ
	23 ⁰ En. ϵ		1 ¹ Di. ϵ		13 ⁷ Mi. η
	23 ⁰ Mi. ζ		10 ⁵ En. ϵ		15 ⁴ Te. θ
5	13 ¹ Te. η		14 ⁷ Mi. ζ		15 ⁷ En. θ
	14 ⁹ Di. ζ		20 ⁶ Mi. η		16 ⁸ Te. Ecl. D.
	15 ⁵ En. η		20 ⁷ En. ζ		17 ⁷ Titan Ecl. D.
	16 ² Mi. ϵ		22 ¹ Te. ζ		19 ¹ Mi. θ
	17 ¹ Di. β	11	0 ¹ Te. β		20 ¹ Rh. ζ
	17 ⁹ Di. Sh.		1 ¹ Te. Sh.		20 ³ Te. α
	20 ⁴ Di. γ		10 ² Rh. β		22 ¹ En. ϵ
	21 ⁶ Mi. ζ		10 ⁸ Rh. Sh.		22 ³ Te. ϵ
	22 ⁶ Di. η		13 ¹ En. θ		22 ⁷ Rh. β
6	11 ⁸ Te. ϵ		13 ³ Mi. ζ		23 ¹ Titan Ecl. R.
	14 ⁸ Mi. ϵ		14 ¹ Rh. γ		23 ³ Rh. Sh.
	18 ⁰ En. ζ		16 ⁷ Rh. η	16	1 ⁰ Mi. ϵ
	19 ³ Rh. ζ		19 ² Mi. η		1 ⁵ Titan sup. ϕ
	20 ² Mi. ζ		19 ⁴ En. ϵ		w. centre
	21 ⁸ Rh. β		20 ⁸ Te. θ		11 ^{''} 1 n.
	22 ⁴ Rh. Sh.		22 ² Te. Ecl. D.		2 ⁵ Rh. γ
	23 ⁷ Di. θ	12	11 ¹ Di. θ		4 ⁵ Titan α
7	0 ³ En. η		11 ⁹ En. η		12 ³ Mi. η
	1 ⁰ Di. Ecl. D.		11 ⁹ Mi. ζ		13 ⁶ Di. ζ
	1 ⁷ Rh. γ		12 ⁴ Di. Ecl. D.		14 ⁰ Te. ζ
	12 ⁵ Titan ζ		16 ⁶ Di. α		14 ⁵ En. η
	13 ⁵ Mi. ϵ		17 ⁸ Mi. η		15 ⁸ Di. β
	14 ¹ Titan Sh.		18 ⁸ Di. ϵ		16 ⁰ Te. β
	16 ³ Titan β		19 ⁴ Te. ζ		16 ⁷ Di. Sh.
	16 ⁸ En. ϵ		21 ⁴ Te. β		17 ⁰ Te. Sh.
	18 ⁹ Mi. ζ		22 ⁰ En. θ		17 ⁷ Mi. θ
	19 ² Titan inf. ϕ		22 ⁴ Te. Sh.		18 ⁹ Te. γ
	with centre		23 ² Mi. θ		19 ¹ Di. γ
	11 ^{''} 1 s.	13	0 ³ Te. γ		20 ⁹ Te. η
	22 ² Titan γ		13 ⁹ Rh. θ		21 ³ Di. η
8	0 ⁸ Mi. η		14 ⁴ En. ζ	17	12 ⁷ Te. θ
	2 ⁰ Titan η		15 ⁰ Rh. Ecl. D.		14 ¹ Te. Ecl. D.
	2 ² Te. θ		16 ⁵ Mi. η		16 ³ Mi. θ
	10 ⁸ Di. β		18 ¹ Te. θ		17 ¹ En. ζ
	11 ⁶ Di. Sh.		19 ⁵ Te. Ecl. D.		17 ⁶ Te. α
	12 ¹ Mi. ϵ		19 ⁹ Di. ζ		19 ⁶ Te. ϵ
	14 ⁰ Di. γ		20 ³ Rh. α		22 ² Mi. ϵ
	16 ³ Di. η		20 ⁸ En. η		22 ⁴ Di. θ
	17 ⁵ Mi. ζ		21 ⁹ Mi. θ		23 ⁴ En. η
	19 ³ En. θ		22 ¹ Di. β		23 ⁸ Di. Ecl. D.
	23 ⁴ Mi. η		22 ⁹ Rh. ϵ	18	11 ³ Rh. ϵ
9	0 ⁸ Te. ζ		23 ⁰ Te. α		11 ³ Te. ζ
	1 ⁵ Rh. θ		23 ⁰ Di. Sh.		13 ³ Te. β
	1 ⁷ En. ϵ	14	1 ⁰ Te. ϵ		14 ³ Te. Sh.
	2 ⁶ Rh. Ecl. D.		1 ⁴ Di. γ		14 ⁹ Mi. θ
	10 ⁵ Rh. ϵ		13 ² En. ϵ		15 ⁸ En. ϵ
	10 ⁷ Mi. ϵ		15 ¹ Mi. η		16 ² Te. γ
	11 ⁸ En. ζ		16 ⁷ Te. ζ		18 ² Te. η
	16 ¹ Mi. ζ		18 ⁷ Te. β	19	10 ⁰ Te. θ
	17 ⁴ Di. θ		19 ⁷ Te. Sh.		10 ⁴ Di. Sh.

G.M.T.		G.M.T.		G.M.T.	
1892.	h	1892.	h	1892.	h
Jan. 19	11'4 Te. Ecl. D.	Jan. 24	13'5 En. ζ	Jan. 29	22'2 Te. Sh.
	12'8 Di. γ		17'9 Mi. ζ		22'3 Mi. θ
	13'5 Mi. θ		18'6 Di. ζ	30	0'0 Te. γ
	14'9 Te. α		19'8 En. η		11'4 Di. γ
	15'0 Di. η		20'8 Di. β		13'6 Di. η
	16'9 Te. ϵ		20'9 Rh. ζ		15'5 Mi. η
	18'4 En. θ		21'8 Di. Sh.		17'4 En. θ
	19'5 Mi. ϵ		23'4 Rh. β		17'8 Te. θ
20	10'6 Te. β		23'8 Mi. η		19'3 Te. Ecl. D.
	10'8 En. ζ	25	0'1 Di. γ		20'9 Mi. θ
	11'0 Rh. β		0'2 Rh. Sh.		22'7 Te. α
	11'6 Te. Sh.		1'9 Te. θ		23'8 En. ϵ
	11'7 Rh. Sh.		12'2 En. ϵ	31	0'7 Te. ϵ
	12'2 Mi. θ		16'5 Mi. ζ		14'1 Mi. η
	13'5 Te. γ		22'3 En. ζ		14'8 Di. θ
	14'9 Rh. γ		22'5 Mi. η		15'4 Rh. θ
	15'5 Te. η	26	0'5 Te. ζ		16'2 En. η
	16'1 Di. θ		11'1 Di. ϵ		16'3 Di. Ecl. D.
	17'2 En. η		14'8 En. θ		16'4 Te. ζ
	17'5 Rh. η		15'2 Mi. ζ		16'8 Rh. Ecl. D.
	17'5 Di. Ecl. D.		21'1 Mi. η		17'0 Titan Ecl. D.
	18'1 Mi. ϵ		21'1 En. ϵ		17'0 Titan θ
	21'6 Di. α		23'2 Te. θ		18'4 Te. β
	23'5 Mi. ζ	27	0'7 Te. Ecl. D.		19'5 Te. Sh.
	23'8 Di. ϵ		9'5 Rh. α		19'5 Mi. θ
21	12'2 Te. α		12'0 Rh. ϵ		20'3 Di. α
	14'2 Te. ϵ		12'3 Di. ζ		21'3 Te. γ
	16'7 Mi. ϵ		13'6 En. η		21'9 Rh. α
	19'7 En. ζ		13'8 Mi. ζ		22'1 Titan Ecl. R.
	22'1 Mi. ζ		14'5 Di. β		22'5 Di. ϵ
22	0'9 Di. ζ		15'5 Di. Sh.		23'3 Te. η
	10'8 Te. γ		17'8 Di. γ		23'8 Titan sup. ϕ
	12'1 En. θ		19'7 Mi. η		w. centre
	12'8 Te. η		20'0 Di. η		10''6 n.
	14'7 Rh. θ		21'8 Te. ζ	Feb. 1	0'4 Rh. ϵ
	15'3 Mi. ϵ		23'7 En. θ		12'7 Mi. η
	15'9 Rh. Ecl. D.		23'8 Te. β		15'1 Te. θ
	18'5 En. ϵ	28	0'9 Te. Sh.		16'6 Te. Ecl. D.
	20'7 Mi. ζ		12'4 Mi. ζ		18'1 Mi. θ
	21'1 Rh. α		16'1 En. ζ		18'7 Ea. ζ
	23'7 Rh. ϵ		18'3 Mi. η		20'0 Te. α
23	10'9 En. η		20'5 Te. θ		22'0 Te. ϵ
	11'0 Titan ζ		21'1 Di. θ		23'6 Di. ζ
	11'2 Di. Ecl. D.		22'0 Te. Ecl. D.	2	11'2 En. θ
	11'5 Te. ϵ		22'4 En. η		11'4 Mi. η
	13'3 Titan Sh.		22'6 Di. Ecl. D.		13'7 Te. ζ
	13'9 Mi. ϵ		23'7 Mi. θ		15'7 Te. β
	14'8 Titan β	29	1'4 Te. α		16'8 Mi. θ
	15'3 Di. α		9'2 Rh. ζ		16'8 Te. Sh.
	17'5 Di. ϵ		11'0 Mi. ζ		17'5 En. ϵ
	17'8 Titan inf. ϕ		11'8 Rh. β		18'6 Te. γ
	w. centre,		12'6 Rh. Sh.		20'6 Te. η
	10''8 s.		14'9 En. ϵ		21'6 Rh. ζ
	19'3 Mi. ζ		15'7 Rh. γ		22'7 Mi. ϵ
	20'7 Titan γ		16'9 Mi. η	3	0'2 Rh. β
	21'0 En. θ		18'2 Rh. η		1'1 Rh. Sh.
24	0'5 Titan η		19'1 Te. ζ		10'0 En. η
	12'5 Mi. ϵ		21'1 Te. β		10'0 Di. Ecl. D.

G.M.T.		G.M.T.		G.M.T.	
1892.	h	1892.	h	1892.	h
Feb. 3	10 ⁰ Mi. η	Feb. 7	19 ⁰ Rh. η	Feb. 14	13 ⁵ Rh. ϵ
	12 ⁴ Te. θ		21 ¹ Mi. ζ		14 ⁸ Di. ϵ
	13 ⁹ Te. Ecl. D.		22 ⁷ En. θ		17 ³ Mi. η
	13 ⁹ Di. α	8	9 ¹ Titan ζ		19 ¹ En. θ
	15 ⁴ Mi. θ		10 ⁵ Te. γ		20 ¹ Te. θ
	16 ¹ Di. ϵ		12 ⁴ Titan Sh.		21 ⁸ Te. Ecl. D.
	17 ³ Te. α		12 ⁵ Te. η	15	11 ⁵ En. ζ
	19 ³ Te. ϵ		12 ⁹ Titan		15 ⁹ Di. ζ
	20 ¹ En. θ		14 ⁴ Mi. ϵ		16 ⁰ Mi. η
	21 ³ Mi. ϵ		15 ¹ En. ζ		17 ⁹ En. η
4	11 ⁰ Te. ζ		15 ⁹ Titan inf. δ		18 ¹ Di. β
	12 ⁵ En. ζ		w. centre		18 ⁸ Te. ζ
	13 ⁰ Te. β		9 ¹¹ 9 s.		19 ³ Di. Sh.
	14 ⁰ Mi. θ		18 ⁸ Titan γ		20 ⁸ Te. β
	14 ¹ Te. Sh.		19 ⁸ Mi. ζ		21 ⁴ Mi. θ
	15 ⁹ Te. γ		19 ⁸ Di. θ		21 ⁴ Di. γ
	17 ³ Di. ζ		21 ⁴ Di. Ecl. D.		21 ⁹ Te. Sh.
	17 ⁹ Te. η		21 ⁵ En. η		23 ⁶ Di. η
	18 ⁸ En. η		22 ⁶ Titan η		23 ⁷ Te. γ
	19 ⁵ Di. β	9	9 ² Te. α	16	10 ³ En. ϵ
	19 ⁹ Mi. ϵ		11 ² Te. ϵ		10 ⁷ Rh. ζ
	20 ⁵ Di. Sh.		13 ⁰ Mi. ϵ		13 ² Rh. β
	22 ⁸ Di. γ		13 ⁹ En. ϵ		14 ⁴ Rh. Sh.
5	9 ⁷ Te. θ		16 ¹ Rh. θ		14 ⁶ Mi. η
	10 ² Rh. α		17 ⁸ Rh. Ecl. D.		15 ⁰ Titan θ
	11 ² Te. Ecl. D.		18 ⁴ Mi. ζ		16 ⁴ Titan Ecl. D.
	11 ³ En. ϵ		22 ⁶ Rh. α		17 ¹ Rh. γ
	12 ⁶ Mi. θ	10	9 ⁸ Te. η		17 ⁴ Te. θ
	12 ⁸ Rh. ϵ		10 ¹ Di. γ		19 ¹ Te. Ecl. D.
	14 ⁶ Te. α		11 ⁶ Mi. ϵ		19 ⁷ Rh. η
	16 ⁶ Te. ϵ		12 ³ Di. η		20 ⁰ Mi. θ
	18 ⁵ Mi. ϵ		16 ⁴ En. θ		20 ⁴ En. ζ
	21 ⁴ En. ζ		17 ⁰ Mi. ζ		21 ¹ Titan Ecl. R.
	23 ⁹ Mi. ζ		22 ⁸ En. ϵ		21 ⁸ Titan sup. δ
6	9 ⁸ Di. ϵ		22 ⁹ Mi. η		w. centre
	10 ³ Te. β	11	13 ⁴ Di. θ		9 ¹¹ 3 n.
	11 ² Mi. θ		15 ¹ Di. Ecl. D.		22 ³ Te. α
	11 ⁴ Te. Sh.		15 ² En. η	17	0 ³ Te. ϵ
	13 ² Te. γ		15 ⁶ Mi. ζ		0 ⁷ Titan α
	13 ⁸ En. θ		18 ⁹ Di. α		0 ⁷ Di. θ
	15 ² Te. η		21 ¹ Di. ϵ		8 ⁴ Di. ϵ
	17 ¹ Mi. ϵ		21 ⁵ Mi. η		12 ⁸ En. θ
	20 ¹ En. ϵ		22 ³ Rh. ζ		13 ² Mi. η
	22 ⁵ Mi. ϵ	12	0 ² Te. ζ		16 ¹ Te. ζ
	8 ⁵ Te. Ecl. D.		0 ⁹ Rh. β		18 ¹ Te. β
	9 ⁸ Mi. θ		14 ² Mi. ζ		18 ⁶ Mi. θ
	10 ⁰ Rh. ζ		17 ⁸ En. ζ		19 ² En. ϵ
	10 ⁹ Di. ζ		20 ¹ Mi. η		19 ³ Te. Sh.
	11 ⁹ Te. α		22 ³ Di. ζ		21 ⁰ Te. γ
	12 ⁵ Rh. β		22 ⁸ Te. θ		23 ⁰ Te. η
	12 ⁶ En. η	13	10 ² En. θ	18	9 ⁶ Di. ζ
	13 ¹ Di. β		12 ⁸ Mi. ζ		11 ⁶ En. η
	13 ⁵ Rh. Sh.		16 ⁵ En. ϵ		11 ⁸ Di. β
	13 ⁹ Te. ϵ		18 ⁷ Mi. η		11 ⁸ Mi. η
	14 ² Di. Sh.		21 ⁵ Te. ζ		13 ⁰ Di. Sh.
	15 ⁷ Mi. ϵ		23 ⁵ Te. β		14 ⁷ Te. θ
	16 ⁴ Rh. γ	14	10 ⁹ Rh. α		15 ¹ Di. γ
	16 ⁴ Di. γ		11 ⁴ Mi. ζ		16 ⁴ Te. Ecl. D.
	18 ⁶ Di. η		12 ⁶ Di. α		16 ⁸ Rh. θ

G.M.T.		G.M.T.		G.M.T.	
1892.	h	1892.	h	1892.	h
Feb. 18	17 ² Mi. θ	Feb. 22	14 ² En. η	Feb. 25	17 ⁸ Rh. γ
	17 ³ Di. η		16 ² Te. ϵ		18 ¹ En. θ
	18 ⁷ Rh. Ecl. D.		17 ⁵ Di. α		18 ⁸ Mi. ζ
	19 ⁶ Te. α		17 ⁶ Mi. ϵ		20 ³ Rh. η
	21 ⁶ Te. ϵ		19 ⁷ Di. ϵ	26	8 ⁸ Te. α
	21 ⁷ En. θ	23	7 ² Rh. Ecl. D.		10 ⁵ En. ζ
	23 ¹ Mi. ϵ		8 ⁰ Te. ζ		10 ⁸ Te. ϵ
	23 ³ Rh. α		10 ⁰ Te. β		12 ⁰ Mi. ϵ
19	10 ⁴ Mi. η		10 ³ Mi. θ		14 ⁵ Di. ζ
	13 ⁴ Te. ζ		11 ² Te. Sh.		16 ⁷ Di. β
	14 ¹ En. ζ		11 ⁶ Rh. α		16 ⁹ En. η
	15 ⁴ Te. β		12 ⁹ Te. γ		17 ⁴ Mi. ζ
	15 ⁸ Mi. θ		14 ² Rh. ϵ		18 ¹ Di. Sh.
	16 ⁶ Te. Sh.		14 ⁹ Te. η		20 ⁰ Di. γ
	18 ³ Te. γ		16 ² Mi. ϵ		22 ² Di. η
	18 ⁴ Di. θ		16 ⁸ En. ζ	27	7 ⁴ Te. γ
	20 ² Di. Ecl. D.		20 ⁹ Di. ζ		9 ³ En. ϵ
	20 ³ Te. η		21 ⁶ Mi. ζ		9 ⁴ Te. η
	20 ⁵ En. η		23 ¹ Di. β		10 ⁶ Mi. ϵ
	21 ⁷ Mi. ϵ		23 ¹ En. η		16 ⁰ Mi. ζ
	23 ⁹ Di. α	24	6 ⁹ Titan ζ		17 ⁵ Rh. θ
20	12 ⁰ Te. θ		8 ⁴ Te. Ecl. D.		19 ⁴ En. ζ
	12 ⁹ En. ϵ		8 ⁹ Mi. θ		19 ⁶ Rh. Ecl. D.
	13 ⁷ Te. Ecl. D.		9 ² En. θ		21 ⁹ Mi. η
	14 ⁴ Mi. θ		10 ⁷ Titan β		23 ⁴ Di. θ
	16 ⁹ Te. α		11 ⁵ Te. α		23 ⁹ Rh. α
	18 ⁹ Te. ϵ		11 ⁵ Titan Sh.	28	7 ⁰ Di. ϵ
	20 ³ Mi. ϵ		13 ⁵ Te. ϵ		8 ¹ Te. ϵ
	23 ⁰ Rh. ζ		13 ⁷ Titan inf. ϕ		9 ² Mi. ϵ
	23 ⁰ En. ζ		w. centre		11 ⁸ En. θ
21	8 ⁰ Rh. η		8 ⁴ s.		14 ⁶ Mi. ζ
	8 ⁷ Di. γ		? Transit		18 ² En. ϵ
	10 ⁷ Te. ζ		14 ⁸ Mi. ϵ		20 ⁵ Mi. η
	10 ⁹ Di. η		15 ⁵ En. ϵ		23 ⁸ Te. ζ
	12 ⁷ Te. β		16 ⁶ Titan γ	29	8 ² Di. ζ
	13 ⁰ Mi. θ		20 ² Mi. ζ		10 ⁴ Di. β
	13 ⁹ Te. Sh.		20 ⁴ Titan η		10 ⁶ En. η
	15 ⁵ En. θ	25	7 ⁶ Di. Ecl. D.		11 ⁸ Di. Sh.
	15 ⁶ Te. γ		8 ⁰ En. η		13 ² Mi. ζ
	17 ⁶ Te. η		8 ⁵ Te. Sh.		13 ⁷ Di. γ
	18 ⁹ Mi. ϵ		10 ¹ Te. γ		15 ⁹ Di. η
	21 ⁸ En. ϵ		11 ² Di. α		19 ² Mi. η
22	9 ³ Te. θ		11 ³ Rh. ζ		20 ⁷ En. θ
	11 ⁰ Te. Ecl. D.		12 ¹ Te. η		22 ⁵ Te. θ
	11 ⁷ Mi. θ		13 ⁴ Di. ϵ		23 ⁷ Rh. ζ
	12 ⁰ Di. θ		13 ⁴ Mi. ϵ	Mar. 1	0 ³ Te. Ecl. D.
	13 ⁹ Di. Ecl. D.		13 ⁹ Rh. β		
	14 ² Te. α		15 ³ Rh. Sh.		

(To be continued.)